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SEPTEMBER 1957

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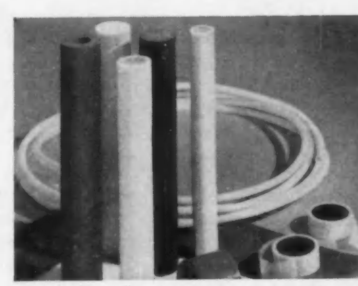

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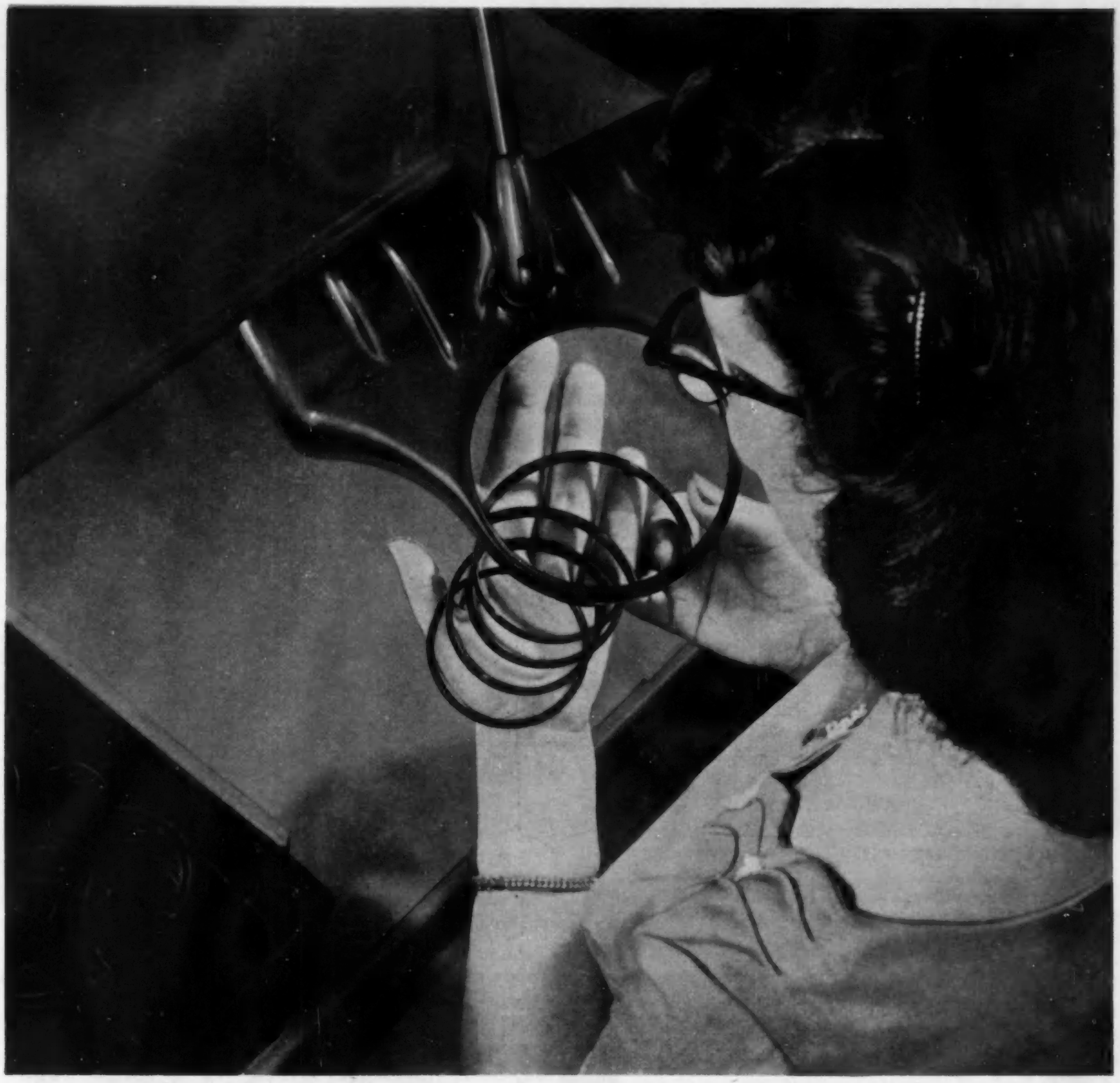

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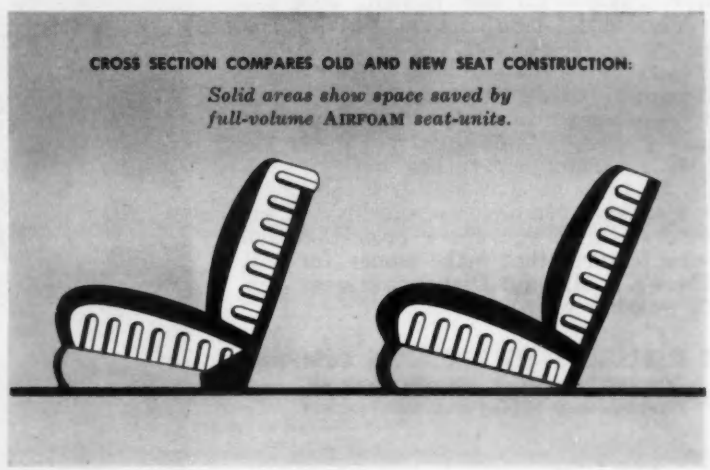

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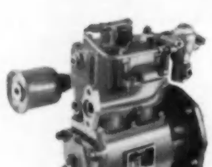

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For the Sake of Argument

Analysis and Action . . .

By Norman G. Shidle

Analysis is a sound first step to solution of most business and engineering problems. But analysis alone never solved anything. Without analysis, solutions are sometimes possible. Without synthesis, focus, and action they never are.

Most of us are more keen to analyze than to act; to take apart than to put together.

"Analysis has to precede intelligent synthesis," we rationalize. "You can't fix a broken clock until you disassemble the parts and find out exactly what's wrong. Only then can you reassemble it correctly."

We're quick to see and state what's wrong with a program or a person . . . but slower to see or state what ought to be done . . . and still slower to *do* what is needed.

Critical analysis comes easy, because, as often as not, it's an emotional gratification.

And analysis is blood-relation to criticism. . . . Criticism is, in fact, the black-sheep brother of analysis. So close is the resemblance that we often mistake one for the other—especially when judging our own "analysis."

Decision and action for correction or solution, on the other hand, is plain hard work for most of us. It brings little emotional gratification until completion of the project . . . at which we arrive all too seldom.

Apathy steps in with uncomfortable frequency, clouds our vision, . . . leaves an error uncovered but uncorrected.

SAE journal

Norman G. Shidle
Editor

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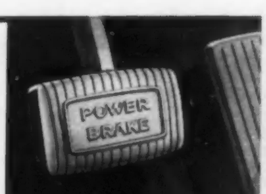

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Radiotracer study points way to make . . .

BY means of radioactive hydrocarbons, present in only tracer amounts, it has been possible recently to draw some very definite conclusions about the effect of gasoline hydrocarbon composition on deposit formation. The most important of these are:

1. The deposit-forming tendency of hydrocarbons goes up strongly with increasing boiling point.
2. Aromatics are much worse deposit formers than paraffins. Olefins are intermediate.
3. The carbonaceous part of combustion-chamber deposits appears to form via a mechanism involving condensation followed by carbonization.
4. Careful control of the high boiling end of the gasoline is needed to make a clean-burning fuel.

In brief, the technique consists of adding to a typical gasoline a very small amount of a radioactive hydrocarbon labeled in one or more positions. The radioactivity of the fuel is measured and the fuel is then burned in a single-cylinder engine. The deposits are collected and their radioactivity is measured. The ratio of the specific activity of the deposits to that of the fuel has been called the "concentration ratio." (Specific activity is the activity per unit weight of carbon.) This ratio is a measure of a component's deposit-forming tendency. The higher the concentration ratio the worse the component. The concentration ratio is the most important measurement obtained in these studies. Fig. 1 shows how this ratio is determined.

Advantages of Radiotracer Technique

This technique has several advantages over conventional methods:

1. It measures the deposit-forming tendency of a component in the concentration in which it actually is present in the gasoline. The gasoline is not unbalanced by the addition of large amounts of the material to be studied. There is no assurance, for example, that toluene present in 50% concentration will behave the same way as when present in 2% concentration. The radiotracer technique uses the labeled material in amounts too small to affect the concentration of the component.
2. By varying the labeled position, it is possible to differentiate not only among compounds, but even among carbon atoms in the same molecule.
3. Results are expressed directly as deposit-forming tendency, not as some other property from which the tendency must be inferred.
4. The test is reproducible.

When using a leaded fuel, about 80% of the deposits is composed normally of lead salts, hence the gasoline hydrocarbons might seem to be of little importance. But this is not true. Cleaner burning hydrocarbons lead to a substantial reduction in deposit weight and harm.

In a controlled field test with two cars, replacing the commercial gasoline with leaded isooctane lowered the deposit weight substantially, cut the deposit volume in half, and reduced the equilibrium octane requirement by 11 units. Moreover, even though the same amount of lead passed through the engine in both tests, there was much less present in the deposits when isooctane was the fuel. This indicates the importance of the carbonaceous part of the deposit, not only in itself, but also because it acts as a matrix to which the lead adheres. Conceivably, if the carbonaceous part of the deposit could be eliminated the entire deposit might disappear. This makes apparent that an improvement in the deposit-forming properties of the gasoline hydrocarbons would be of great value in all aspects of engine performance affected by combustion-chamber deposits.

Experimental Results

The deposit-forming tendency of hydrocarbons rises strongly with increasing boiling point. This is especially obvious with aromatics, as shown in Fig. 2, and is probably the most important consideration in the design of a clean-burning gasoline. (Fig. 2 shows the average concentration ratios throughout the combustion chamber at the end of the runs.) For example, isohexyl toluene boiling at 465 F has a concentration ratio of 6.06 and forms almost 14 times as many deposits at a given fuel

Clean-Burning Gasoline

Based on paper by **L. B. Shore and K. F. Ockert,** Esso Research and Engineering Co.

concentration as toluene, which boils at 213 F. The increase in concentration ratio becomes especially large at a boiling point just below 400 F.

At a given boiling point, aromatics are more harmful than paraffins, while the olefins are intermediate. This has long been suspected, but quantitative data giving the magnitude of the differences are only now available. The results in Fig. 2 indicate that the concentration ratio of paraffins goes up with the boiling point in the same way as the concentration ratio of aromatics. At a given boiling point the aromatics are nearly three times worse than paraffins, but there is little change in their relative harm as the boiling point increases.

Boiling point seems to be the only factor in determining the deposit-forming tendency of aromatics. In other words, as long as a compound contains at least one aromatic ring, its deposit-forming tendency can be predicted from its boiling point alone. Four kinds of aromatics were evaluated: toluene and two of its derivatives; one benzene derivative; indane, an aromatic alicyclic compound; and naphthalene, a condensed ring aromatic. Plotted against boiling point, all concentration ra-

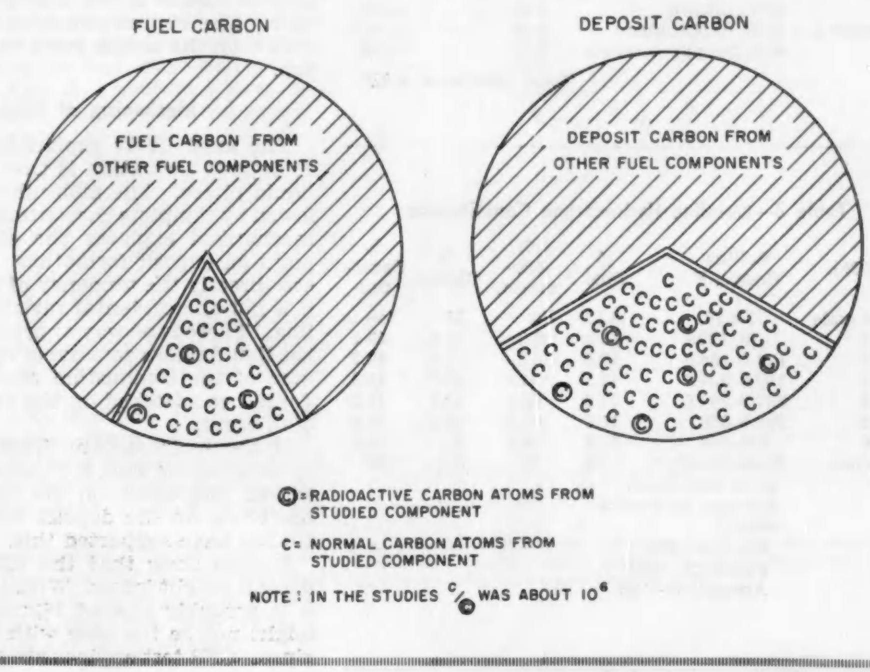


Fig. 1—How concentration ratio is determined.

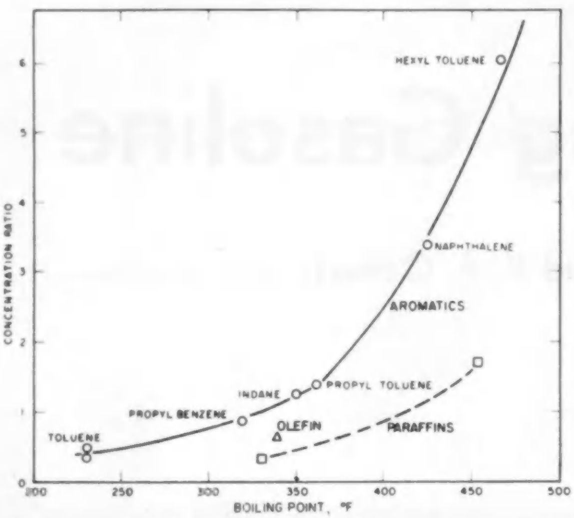


Fig. 2—Deposit-forming tendency of hydrocarbons goes up with increasing boiling point. Aromatics are most strongly affected.

Table 1—Calculation of Deposit-Forming Tendency

	Components		Concentration Ratio	Deposit-Forming Tendency
Gasoline 1	20%	toluene	0.44	0.088
	70%	naphthalene	3.40	2.380
	10%	propyl benzene	0.86	0.086
			Total gasoline=	2.554
Gasoline 2	60%	toluene	0.44	0.264
	10%	naphthalene	3.40	0.340
	30%	propyl benzene	0.86	0.258
			Total gasoline=	0.862

Table 2—Gasoline Hydrocarbon Constituents

Cut No.	Boiling Range, F	% Fuel	% Aromatics	% Olefins	% Paraffins
Light ends	To 78	6.13	0	60	40
1	78–127.4	18.0	0.9	59.0	40.1
2	127.4–186.8	12.9	8.4	42.4	49.2
3	186.8–237.2	17.3	24.1	27.7	48.2
4	237.2–287.6	20.0	40.7	18.1	41.2
5	287.6–338	16.0	57.5	12.9	29.6
6	338–388	6.13	79.0	6.4	14.6
Bottoms	Undistillable at 50 mm of Hg.	1.73	67	3.0	30

Average molecular weight:
Olefins—290
Paraffins—290
Aromatics—178

tios fall on the same smooth curve with almost no scatter.

In an aromatic, all carbons in the molecule are equivalent in tendency to make deposits. If there were any striking differences, it is extremely unlikely that the concentration ratios would fall on a smooth curve as they do. The effect of location of the labeled atom would be superimposed on the boiling point effect and would cause scatter. Since there is no scatter, it is inferred that there is no effect of carbon atom location.

On any one surface the concentration ratios do not change systematically as the deposits build up. In several tests, the engine head was removed at intervals and small amounts of deposit were removed and analyzed. No systematic differences were noted.

Concentration ratios do not change with time. For example, 20-hr results are a mixture of the layer formed during the first 10 hr plus the layer formed during the second 10 hr. The deposits formed toward the end of the test could be substantially different from those formed earlier without materially affecting the results. This is especially true since less material is formed per unit time as the test continues, due to the increasing surface temperature as the deposit accumulates. For these reasons it is impossible to be absolutely certain that deposits formed on old deposits are identical in their sources with those formed on clean surfaces.

There is an effect of deposit location on concentration ratio, due probably in the main to differences in surface temperature throughout the engine. Analysis of deposits from separate locations revealed deposits having a high per cent of carbon had a generally lower concentration ratio. This is shown in Fig. 3. Per cent of carbon in the deposit is felt to be not in itself the important variable but rather a measure of the average temperature of the surface on which the deposit is formed. The higher the per cent of carbon in the deposit the lower its temperature. The concentration ratio is almost invariably lowest on the intake valve and highest on the piston top.

Mechanism of Deposit Formation

The most likely explanation for the mechanism of deposit formation is that they are formed via a liquid phase. The molecules are first liquified, followed by complete carbonization in that phase. This mechanism explains the strong effect of boiling point on deposit formation. Boiling point will govern directly the tendency of a compound to liquefy; it is not an accidental variable but is really controlling. There is no way at present of knowing whether the liquid phase consists of droplets in the main volume of the combustion chamber or of liquid condensed or adsorbed on the chamber walls. Perhaps both occur.

If the hydrocarbons form deposits by first condensing on the wall, increasing the wall temperature should cut down on the condensation rate and, therefore, on the deposit formation. A number of studies have supported this.

Studies show that the lubricant contribution to deposit weight is low. With the full boiling gasolines it is probably around 2%; at most it is 8%. This might not be the case with typical automotive engines. CFR test engines are designed for very low oil

consumption. Moreover, the lubricant used was of high quality, that is, low deposit-forming tendency. In automotive engines the contribution might be substantial and should not be neglected without good reason.

Tendency to Form Deposits

Obviously, the deposit-forming tendency of the hydrocarbon part of an entire gasoline can be determined from the deposit-forming tendencies of the individual components. The weighted average of the concentration ratios of the components will give a number proportional to the deposit-forming tendency of the hydrocarbons in the fuel. This is demonstrated by the simple, hypothetical example shown in Table 1. It shows that the hydrocarbon part of gasoline No. 1 will form about three times as many deposits as the hydrocarbon part of gasoline No. 2.

The deposit-forming tendency is directly proportional to the sum of the concentrations times the concentration ratios. The concentration ratios may be read directly from Fig. 3, or more conveniently from the semilog plot (Fig. 4). The concentrations may be determined by conventional analytical techniques. Thus the relative deposit-forming tendencies of gasoline can be readily calculated without expensive engine testing.

Where the Deposits Come From

A base gasoline was cut into fractions and each fraction analyzed separately for hydrocarbon type. The results are shown in Table 2. When the light ends were evaluated it was found that this top 98.3% of the gasoline contributed only 35% of the carbonaceous part of the deposits, which means that 65% of the deposit must have come from the bottom 1.73% of the gasoline.

This is difficult to check. The greatest difficulty lies in estimating the boiling point of the aromatic fraction of the bottoms. An aromatic of a molecular weight of about 178 can have a boiling point anywhere from 507 F for a normal alkyl benzene to 672 F for anthracine. Also, it is necessary to extrapolate the curves in Fig. 4 well beyond the experimental data. Nevertheless, the value of 0.65 does not appear unreasonable for the gasoline bottoms. By estimating the boiling point from the molecular weight, the paraffin contribution is calculated to be about 0.16 and the olefin contribution about 0.02. If the aromatics are alkyl benzenes, the aromatic contribution is 0.13. If the aromatics are all polynuclear, the aromatic contribution is about 1.1. The aromatics are probably therefore a mixture of alkyl benzenes and polynuclear materials and the 1.73% bottoms can cause 65% of the carbonaceous part of the deposits.

The moral is clear. To make a clean-burning gasoline, look to the bottoms. Keep the heavy material out. With the aid of these precepts it's possible to make an exceptionally deposit-free gasoline, simply by keeping a careful check on its hydrocarbon constituents.

(Paper, "Combustion-Chamber Deposits—A Radioactive Study," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

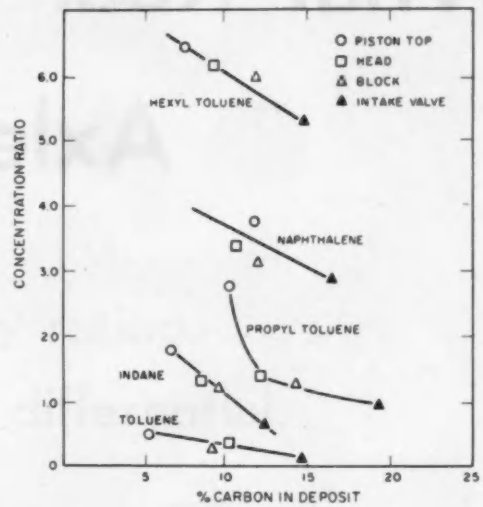


Fig. 3—Deposit location affects concentration ratio due mainly to differences in surface temperature. This is shown for five aromatics.

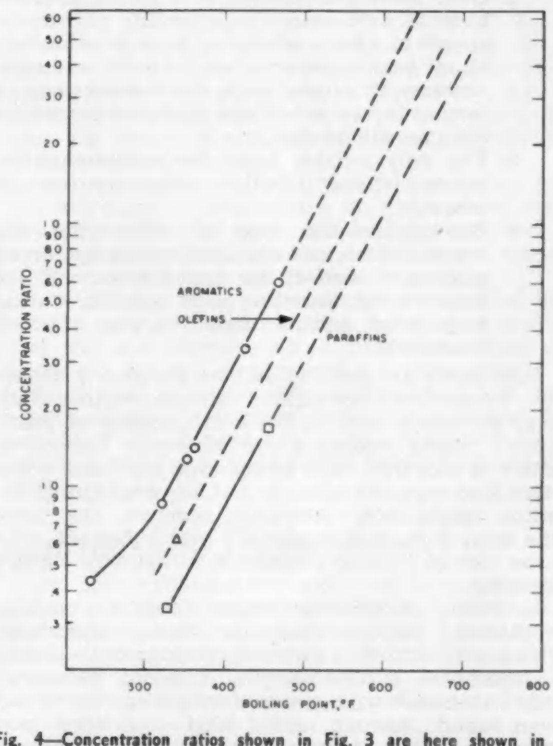


Fig. 4—Concentration ratios shown in Fig. 3 are here shown in a semilog plot. Deposit-forming tendency is directly proportional to sum of concentrations times concentration ratios.

What Rear Axles Need . . . are 1. 2. 3. 4.

EXTENSIVE laboratory and field tests of rear axles indicate:

1. The capacity of present axles can be increased, without increasing axle size, when greater load-carrying antiwear and antiscore lubricants are available.
2. Gear noise will always be a major problem because axle gears are operating at varying speeds and loads whenever a car is in motion. Many gear noise problems can be overcome, however, by proper tooth development and by testing in the actual car model under which the axle will be used.
3. The only reliable basis for torque-capacity rating is the tractive effort (wheel-slip torque).
4. The limited-slip type of differential will eventually become standard equipment on all passenger cars—if for one reason only—to improve car handling and stability during high-speed driving under varying traction conditions.

Lubricants are limiting axle load-carrying capacity. To provide more surface capacity, various additives are being used in the compounding of lubricants. These additives are generally classed as active or inactive. The active-type lubricant offers more load-carrying capacity but has wear and lubrication limitations. Recently, however, the trend has been toward the inactive-type lubricant with some sort of surface treatment to increase surface capacity.

Lubrizing, an iron-manganese-phosphate coating, is probably the most common surface treatment. This treatment offers an initial resistance to scoring and provides a load-carrying capacity previously only obtainable with the active lubricants. It has been found, through actual field experience, that proper lubrizing of the gear set eliminates failures due to scoring during the break-in period.

With the increased loading introduced by automatic transmissions at low speeds, lower axle ratios, and increased sliding due to the use of hypoid gears, lubricity has become a very important factor. Inactive-type lubricants are improving, and with continued development, we eventually may have a lubricant with all the load-carrying advantages of the active lubricants and the desirable antiwear and lubricity features of the inactive lubricants.

Noise

Noise is the major problem in axle design and manufacture. The actual load on gears and bearings is limited to a practical value, with the particular design of axle determined from a noise standpoint rather than a breakage standpoint. Gears must have several teeth in contact to provide quiet operation. Bearings must be properly aligned to prevent bearing noises. Allowable loading must also be given consideration.

Axle noise cannot be controlled by design alone. The introduction of gear-cutting and heat-treating errors reduce the load-carrying capicity of an axle if noise is the consideration. So the development of the gear set is of prime importance. Assuming that we have an axle of practical design, the gear set must be developed to provide a tooth bearing that can be controlled in cutting, heat treating, and lapping, and also meet all requirements of loading under a particular vehicle. This phase of axle manufacture is often overlooked.

There are very few noise problems that cannot be overcome by development. In fact, proper analysis of the noise problem may save considerable redesign and redevelopment. The use of noise or vibration analyzing equipment will generally give clues to any problems. But the only known method of determining whether an axle will be satisfactory from a noise standpoint is to check it out under the vehicle. Changes in vehicle design often require changes in the noise requirements of the axle.

Manufacturing controls are extremely important in producing axles with a satisfactory noise limit. Each heat of steel must be handled individually throughout the manufacturing and heat-treat proc-

Based on paper by **R. P. Lewis** and **L. J. O'Brien,** Dana Corp.

Better lubricants.

Less noise.

A reliable torque-capacity rating.

Some sort of limited-slip differential.

esses. Accuracy of the carriers and component parts must be controlled. And parts must be properly assembled. The extent to which manufacturing can control these items is a major factor in the design of a particular axle for a given vehicle.

Axle Capacity

Fig 1 shows axle loading for the period from 1930 to the present. Note that there has been little change in allowable loading from tractive effort (wheel-slip torque). There has been a considerable change in loading, however, in low gear due to automatic transmissions and in direct drive due to larger engines. Throughout this period, axle size has remained somewhat constant.

In analyzing Fig. 1 further, note that sometime between 1945 and 1950 a point was reached where tractive effort was no longer the maximum load. Now low-gear loading may be several times the tractive effort. This condition no longer permits the use of low-gear torque as fair indication of axle loading for the following reasons:

1. Axle manufacturers have to provide the most economical size axle for each application.
2. Full advantage is not taken of design improvements and the features of the carrier-type axle.
3. Automobile characteristics have changed considerably. Cars have much more horsepower and the low-gear transmission ratio has approximately doubled.
4. The old methods used for axle evaluation were devised by the gear and bearing manufacturers and not the axle manufacturers. Allowable loads on gears and bearings vary with the rigidity and accuracy of the axle being used. The limits which were set up do not provide for this or for improvements in manufacture.
5. Correlation with field experience was inadequate and selection of axle size was based on laboratory tests alone.

Our efforts converged toward developing a method which would take full advantage of experience on all axles and which would disregard axle size. Since the load-carrying capacity of a gear set depends directly on the way the gear set is held in position in the assembly, we plotted the major deflections of gear set against actual field loading for our complete line of axles. And since allowable bearing load depends on the bearing mounting, bearing alignment, and lubrication, we also plotted the field loading on each bearing for each of the axles. We use these curves as a basis for all improvements in design, the design of new axles, and for the selection of an axle of given size.

We compare curves of lift, side movement, and end movement; tooth loading for direct drive, tractive effort, and low gear; and axle bearing load of new design axles to see that loads do not exceed those of satisfactory production axles.

In analyzing these charts and the history of axle loading over a period of years it becomes obvious that the only consistent load that can be used for passenger-car axle design is the tractive effort. It is reasonable to expect that tractive effort will offer a good design requirement because it indicates the load that will be used to propel a vehicle of given weight under various conditions throughout the life of the vehicle.

Limited-Slip Differential

The conventional differential used in today's passenger cars and trucks offers definite limitations to performance under a variety of driving conditions. We can therefore expect that it will be necessary to provide some form of lmited-slip differential to overcome these limitations. A good locking differential must:

1. Maintain differential action.
2. Prevent shock loads and the transfer of engine torque to one axle shaft. Therefore, it must not be of the full-locking type.
3. Provide sufficient traction torque to the non-

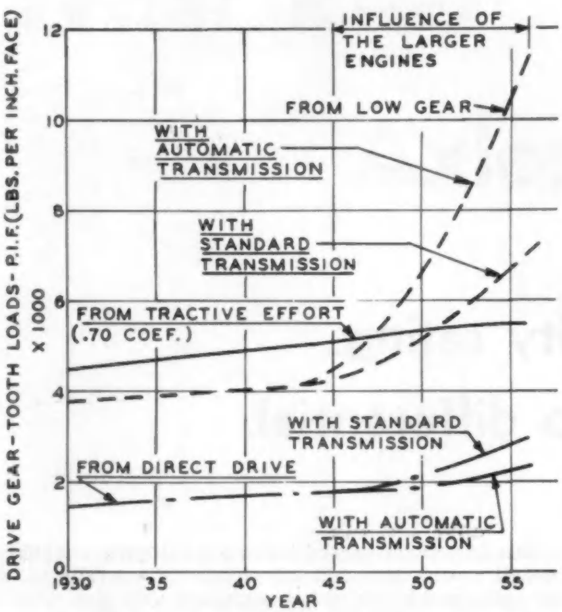


Fig. 1—Rear-axle drive-gear loads from 1930 to present. Note the effect the larger engines and automatic transmissions have had on these loads.

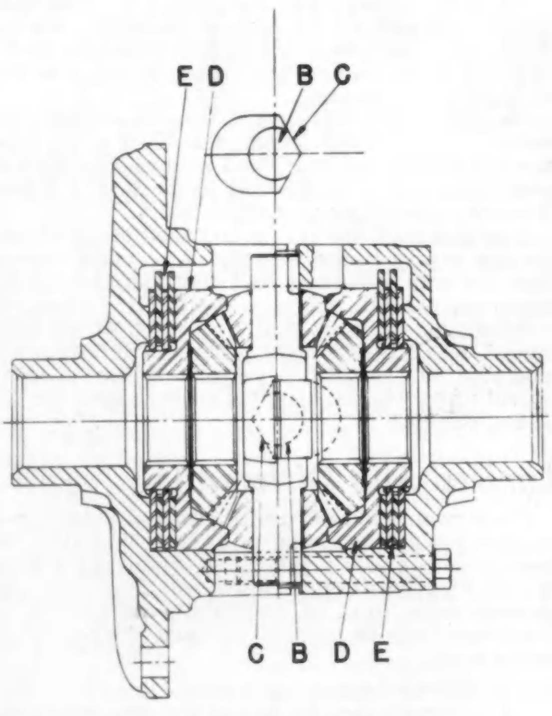


Fig. 2—Thronton Powr-Lok differential.

spinning wheel at all times and under all operating conditions.

4. Not interfere with steering.
5. Have long life and not be subjected to abnormal loads or wear.
6. Continue to function efficiently regardless of the amount of wear.
7. Be quiet in operation.
8. Be of minimum cost, size, and weight.
9. Be a unit that can be used without major design changes in today's axles.

The Thornton Powr-Lok differential appears to fulfill all the above requirements and have some additional advantages. One, for instance, is that action in the Thornton differential is the same for both drive and coast loads and forward and reverse driving. Also, in the Thornton Powr-Lok the capacity is greater than conventional differentials as the load is divided between the gear teeth and the clutches. Fig. 2 shows a Thornton Powr-Lok unit.

The torque is transmitted from the differential case to the cross pins and differential pinions to the side gears in the same manner as torque is applied in the conventional differential. The driving force moves cross pins *B* up to the ramp of the cam surface, *C*, applying a load to the clutch rings, *D*, and restricts turning of the differential through the friction surfaces of the clutches at *E*. This provides a torque ratio between the axle shafts which is based on the amount of friction in the differential and the amount of load that is being applied to the differential.

When turning a corner this process is, in effect, partially reversed. The differential gears become a planetary gear set with the gear on the inside of the curve becoming a fixed gear of the planetary. The outer gear of the planetary overruns as the outside wheel on the curve has a further distance to travel. With the outer gear overrunning and the inner gear fixed, the pinion mates are caused to rotate. Inasmuch as they are restricted by the fixed gear, they first must move the pinion mate shafts, *B*, back down the cam surface, *C*, relieving the thrust loads on the clutches, *E*, when turning the corner.

The Thornton Powr-Lok differential, for all practical purposes, is similar to a conventional differential and the wheels are free to rotate at different speeds. The engagement of the clutches, however, provide many features in this unit that are not common in other types of locking differentials. On straight driving, the clutches are engaged and thus prevent momentary spinning of the wheels when leaving the road or when encountering poor traction. When turning a corner, the load is relieved from the clutch surfaces, so that wear is reduced to a minimum.

Field experience with the Thornton Powr-Lok differential has indicated that shock loads are less severe than with the conventional differential. This is because wheel spinning is reduced to a minimum. Shock loading on the axle and the drive train is also reduced due to the fact that the wheel does not spin and suddenly obtain traction imposing a shock load on the axle and drive line.

(Paper, "Rear Axles—Today—Tomorrow" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Here's what one engineer says, who feels

Large Turbojet Engines Will Beat Out Small Ones for LARGE AIRCRAFT

Based on paper by **C. A. Grinyer,**
vice-president of engineering and chief engineer, Orenda Engines, Ltd.

SMALL turbojets, despite their lower thrust-weight ratio, are not really competitive with large engines for large aircraft. While installed weight would be about the same, the frontal area would be greater for the small engines and cost per pound of thrust would be several times greater.

To show how this would work out in a particular case, let us assume we are considering the installation of both types of engine in an aircraft requiring 72,000 lb of take-off thrust (Fig. 1), as follows:

1. Four 18,000-lb engines.
2. Thirty-two 2250-lb engines.

Since an aircraft of this size would probably have a wing chord of about 25 ft, it will be seen that the buried installation (Fig. 1b) necessitates very long intakes and jet pipes. Thus, with 16 engines in each wing, the wing structure would be penalized and space that might conceivably be used for fuel tanks would be considerably reduced. No value of relative frontal area has been given for this installation but it is apparent if the frontal area required to swallow the air approaches that of the wing then the engines cannot be buried. At the cruise altitude of such an aircraft, the engine performance and intake efficiency will certainly deteriorate, due to Reynolds number effect.

In Fig. 1c we have considered a podded arrangement of small engines. The largest number of pods which one can use in order to avoid interference drag effects is probably eight. Thus, each pod will contain four engines. Nevertheless, making allowance for external piping and control systems the frontal area of such a pod will be approximately 1.8 times that of the 18,000-lb engine pod. In order to attain a satisfactory aerodynamic shape for the pod and to obtain good flow into the engines and avoid base drag, the pod would probably have to be about the same length as for a single engine pod.

If interference effects demand the use of only four pods with eight engines in each, the relative frontal area increases to 2.2. Again the overall length of the pod will be equal to or greater than that of an 18,000-lb engine pod.

With regard to the problem of control and supply of fuel to a large number of engines, it is presumed that a single control system would be used to control at least all the engines in one pod. Each engine would have to contribute an equal share of bleed air for driving the single turbine pump to avoid over-temperature on any one engine. Satisfactory fuel distribution, although necessitating extensive piping, could probably be achieved in podded engines, but it would be very difficult with buried engines, particularly at high altitude when fuel flows and burner pressures are very low.

In considering the application of small engines to interceptor aircraft, which today, ignoring the lightweight fighter, appear to require take-off thrusts of 18,000 lb or greater, clusters of small engines appear

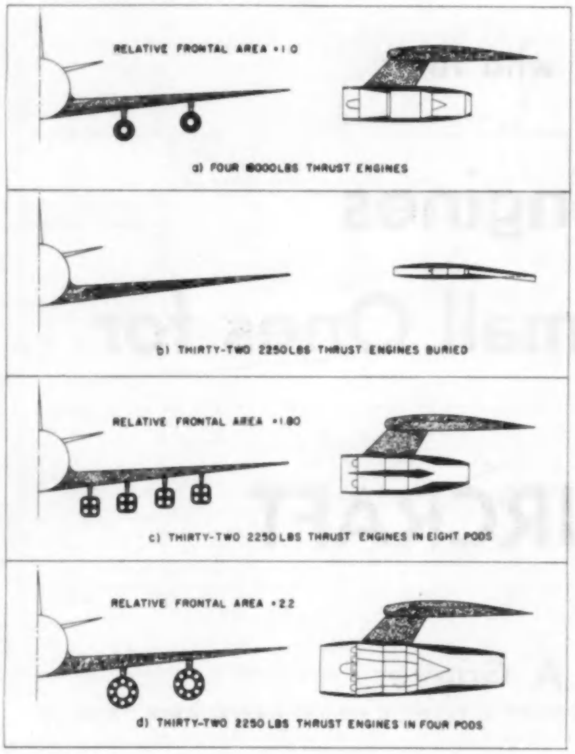


Fig. 1—Comparison of 2250-lb and 18,000-lb thrust turbojet engines in large aircraft requiring 72,000 lb of take-off thrust.

undesirable because of frontal area considerations.

In comparing large and small engines, another consideration which cannot be ignored is the matter of cost. While it is unlikely that the small engine can incorporate the necessary degree of aerodynamic refinement to achieve the performance possible with large engines, if we assume that it could, then it would contain approximately the same number of parts. Because of the finer tolerances required on the parts for the small engine, the manufacturing cost, even though the amount of machining is less, would probably be equal to that of the large engine. The cost of the large engine would, therefore, only be greater by the amount of the increased material cost. It is thus difficult to avoid the conclusion that eight 2250-lb thrust engines would cost several times that of one 18,000-lb engine.

Excerpts from Discussion . . .

A. T. Gregory, Fairchild Engine & Airplane Corp. It is a mistake to expect the small engine to do the same job as a large engine. The small unit has its own particular field of application.

"Clusters" or multicylinder engines were promising from some viewpoints but introduced a number of new problems. They may be designed so that failure of any one will not affect the others. Now it is more customary in the interests of saving weight to treat the cluster as a multicylinder engine with common accessories.

One proposal used a common combustion chamber with several cans or annular burners, so that all compressors and turbines operated at the same pressures. Much remains to be done in the development of this type of engine.

Harry Pearson, Rolls-Royce, Ltd. The advantage of the small engine was supposed to be low weight per pound of thrust, but cost is the most important factor to the commercial operator. In this respect, I feel that the fundamentals of fatigue are being overlooked. The small engine, operating at higher rpm than the large engine, accumulates fatigue cycles faster and should, therefore, have a shorter life and cost more to operate.

Raymond Capiaux, Curtiss-Wright Corp. It should be noted, however, that the small turbojets could use much shorter blades with aspect ratios as low as 2, which would reduce the vibration problems.

(Paper, "Large Lightweight Turbojet Engines," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Engine-Mounted Accessories . . .

. . . may be in trouble when fuel is used as a heat sink. Why not put the accessories in the wings?

Based on paper by **J. D. Delano,** Aircraft Gas Turbine Div., General Electric Co.

ONE way to overcome the difficulties of using fuel as a heat sink in the cooling of engine-mounted accessories is to remove the accessories from the engine pods. All accessories not absolutely necessary to the engine can be located in a package in the wing.

For the sake of argument, let's assume the accessories are mounted on a gearbox driven by a shaft running through the pylon supporting the engine. The resulting arrangement can be shown to be easier to cool, lighter, aerodynamically cleaner, easier to maintain, produce, and stock; and less of a fire hazard.

A schematic of the aircraft and engine accessory

systems is shown in Fig. 1. Contrast this with Fig. 2 which presents a cutaway of the engine pod and a section of the wing, showing the proposed method of driving accessories. The chord of the typical aircraft wing is some 26 ft at the juncture with the strut. A 5% thickness ratio wing will be 15 in. at the maximum point, providing adequate space for the accessories. Fig. 3 gives a layout of the engine accessory package containing all engine and aircraft accessories.

Comparison of Heat Loads

The limiting fuel temperature of the coolers is difficult to predict because it is dependent upon the heating of the fuel as it approaches the nozzles. A safe limit appears to be in the range of 225 F, with a gradually rising future trend. But this limit does exist, hence it is important to take steps to reduce the ambient heat input to the accessories and to protect them from the high ambient temperature. By simply locating the uninsulated accessories in the wing, the fuel temperature rise is comparable to that of engine-mounted accessories with insulation. From this aspect, then, there is a weight saving in insulation.

A comparison of weights of the two systems of mounting show a weight saving of about 84 lb with wing mounting. While this is not precise, it does indicate that the advantages of the wing location can be had with little or no weight penalty.

Removal of engine accessories will effect a reduction in frontal area of some 1.9 sq ft per engine. One method used to calculate engine nacelle drag consists of a wave drag coefficient of 0.1 based on frontal area. Using this factor, drag reduction per engine proved to be 63, 143, and 253 lb at Mach No. 2.0, 3.0, and 4.0 respectively. Considering the total effect per airplane, these values represent a significant saving in fuel consumed.

Maintenance

Remote accessory location will facilitate engine removal, since the engine is cleaner. Although there are more disconnect points, recent development of quick disconnect fittings obviate any extreme difficulties. In the future, several connections will be gathered into one housing to reduce the number of fitting stations.

Most engine model changes are prompted by differences in accessory configuration to meet the requirements of each aircraft application. If the proposed concept were adopted, the same gas generator could be installed in several aircraft without modification and they could be produced in longer production runs.

Similar cost savings would be realized in the stocking of gas generators for replacement. The number of spares could be reduced in logistic estimates, since deviations from the normal attrition rate could apply to all applications.

The majority of aircraft fires are in the powerplant section, and of these the greatest portion is due to the impingement of combustible fluids on hot engine parts. With many of the sources of possible leakage and rupture removed, the incidence of fires should be appreciably reduced.

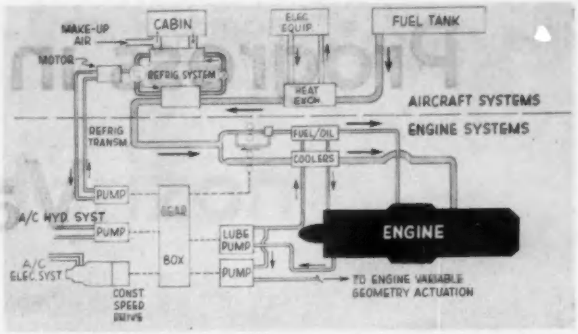


Fig. 1—Schematic of the aircraft and engine accessory systems. This should be viewed in relation to Figs. 2 and 3.

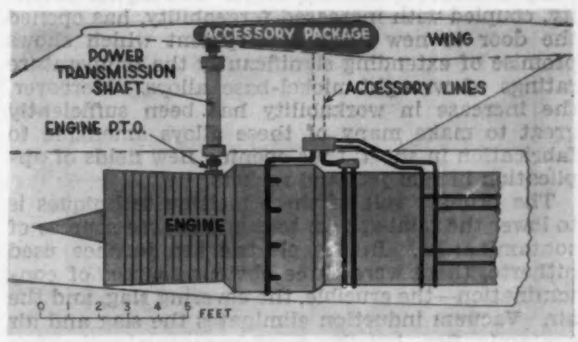


Fig. 2—Side view of remotely driven accessory arrangement. The accessories are removed from the engine pods and located in the wing remote from high heat.

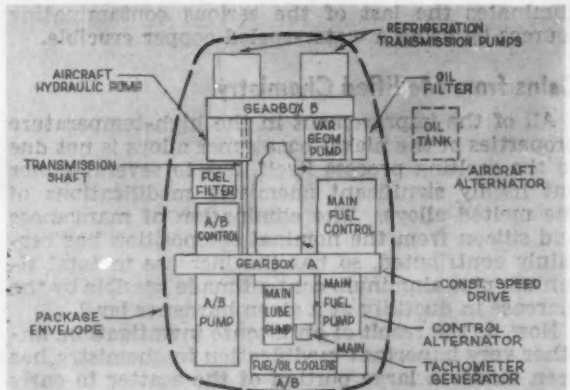


Fig. 3—All of the engine and aircraft accessories are located in this one package, which is placed in wing. The additional aircraft fuel-oil and fuel-air heat exchangers are not shown.

(Paper "Accessories For High Mach No. Engines" on which this abridgement is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Progress in Vacuum Melting

IMPROVED properties of super alloys achieved by vacuum melting have resulted in higher service temperatures for existing alloys. The higher ductility, coupled with increased forgeability, has opened the door to new alloy development which shows promise of extending significantly the temperature ratings of wrought nickel-base alloys. Moreover, the increase in workability has been sufficiently great to make many of these alloys amenable to fabrication in sheet, thus opening new fields of application in ram jets and rockets.

The primary role of these melting techniques is to lower the total gas content and reduce sources of contamination. In the electric arc furnace used hitherto, there were three obvious sources of contamination—the crucible, the covering slag, and the air. Vacuum induction eliminates the slag and air contamination, but the crucible contamination has not been solved by this technique. In this type of melting, deoxidation usually is carried out by carbon or hydrogen which produces gaseous deoxidation products which can be drawn off through the pumping system. The vacuum cold crucible arc furnace eliminates the last of the serious contaminating sources by using a water-cooled copper crucible.

Gains from Modified Chemistry

All of the improvement in the high-temperature properties of the nickel-base super alloys is not due to the melting process itself, but to several minor but highly significant chemistry modifications of the melted alloys. The elimination of manganese and silicon from the nominal composition has certainly contributed, so has the increase in total titanium plus aluminum content made possible by the increase in ductility at a given hardener level.

Now, as the result of an intense investigation, another very important modification in chemistry has been made: a large portion of the scatter in early vacuum-melted heats can be accounted for. Although the cause is related to melting practice, it is due actually to a difference in chemistry not noted in casual chemical analyses of the heats in question. Very small residuals of boron (0.005/0.01%) and zirconium (0.05/0.1%) were found to exhibit a tremendous beneficial effect on rupture life and ductility of various super alloys, and this effect, or at least the level of the elements necessary to produce it, is greatly emphasized in vacuum melting. It was discovered, furthermore, that these elements could be introduced accidentally by contamination and thus account for a large portion of the scatter. Zirconium, for instance, could be introduced into a heat melted in a zirconia crucible, and it was supposed that boron found its way into these heats by its presence in small amounts in the raw material.

Investigators at the University of Michigan have now discovered that boron contents of 0.002% may be introduced by contamination from magnesia crucibles and that even this level can increase greatly the rupture life and ductility of vacuum-melted Udimet 500. Incorporation of these elements into recent chemical specifications for certain vacuum-melted nickel-base super alloys has resulted in significant improvement in the average rupture life and ductility, and also has greatly reduced the scatter due to uncontrolled amounts of boron and zirconium at very low levels where the effect of minor variations is the greatest.

Evaluation of Super Alloys

Since installation of a 1000-lb vacuum induction melting facility at Universal-Cyclops, many heats of various nickel-base super alloys have been melted and evaluated. Most of this evaluation has been stress-rupture and tensile tests at temperatures and stress levels dictated by pertinent specifications covering these materials. However, it was deemed desirable to determine the rupture and tensile properties over a range of temperatures and stresses in order to obtain design data which might be utilized in applying these new alloys. For this purpose, J-1570, GMR-235, Udimet 500, M-252 and Waspaloy were chosen. The grade, heat number, and chemical analyses of these heats are shown in Table 1.

The manganese and silicon contents of all materials were less than 0.02%. The titanium and aluminum contents of the Waspaloy heat have been increased consistent with new specifications issued on the basis of vacuum-melting procedures. Boron was added to all heats (0.1% for GMR-235, and 0.0018–0.006% for others), and zirconium additions (0.04–0.1%) were made to J-1570, Udimet 500 and M-252.

Elevated temperature tests were conducted on the heat-treated specimens using a nominal strain rate of 0.05 in./in./min at temperatures from 1000 to 1600 F. The results of these tensile tests are plotted in Fig. 1. Both tensile and rupture strengths were plotted parametrically, and by way of example, the parameter curves for GMR-235 are shown in Fig. 2.

The effect of vacuum melting on the ductility of M-252 and Waspaloy is shown in Fig. 3 in which the 1500 F tensile strength, tensile ductility, 100-hr rup-

Based on paper by **F. M. Richmond,** Universal-Cyclops Steel Corp.

Opens New Horizon

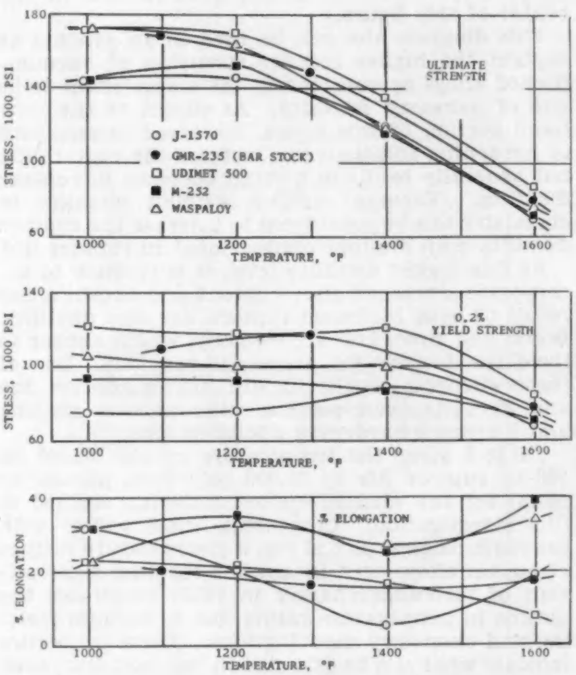


Fig. 1—Tensile properties as a function of test temperature for five vacuum-melted super alloys.

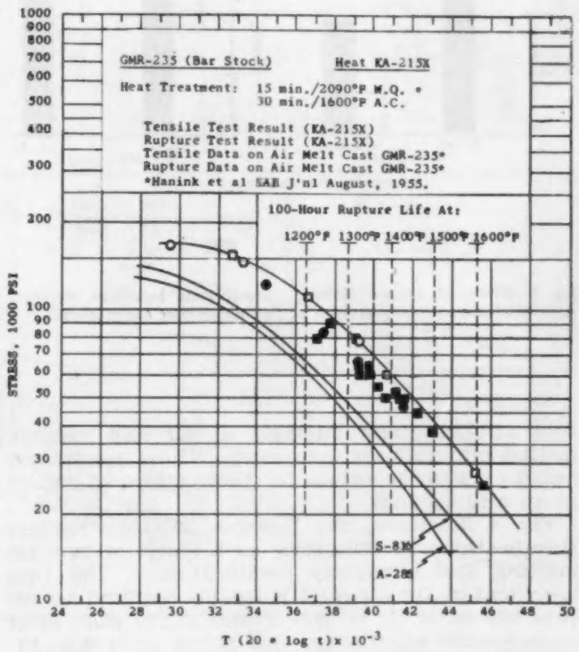


Fig. 2—Tensile and rupture strengths of super alloy GMR-235 plotted parametrically.

Table 1—Chemical Compositions

	Heat No.	C	Cr	Ni	Mo	Co	Al	Ti	Fe	W	B	Zr
J-1570	KA-173X	0.14	19.86	29.58	—	36.60	—	4.38	1.65	7.18	0.0018	(0.04)
GMR-235	KA-215X	0.093	15.51	63.85	5.42	—	2.86	2.11	10.59		0.10	
Udimet 500	KA-277X	0.055	16.18	54.30	4.12	17.96	2.84	3.24	1.50		0.0025	0.096
M-252	KA-195	0.110	18.98	56.95	9.55	9.99	1.05	2.52	0.52	—	(0.005)	0.048
Waspaloy	KA-175	0.065	20.04	55.85	4.10	14.12	1.26	3.22	0.69	—	0.0062	

Note: Figures in parentheses are nominal aims; all others are actual analyses.

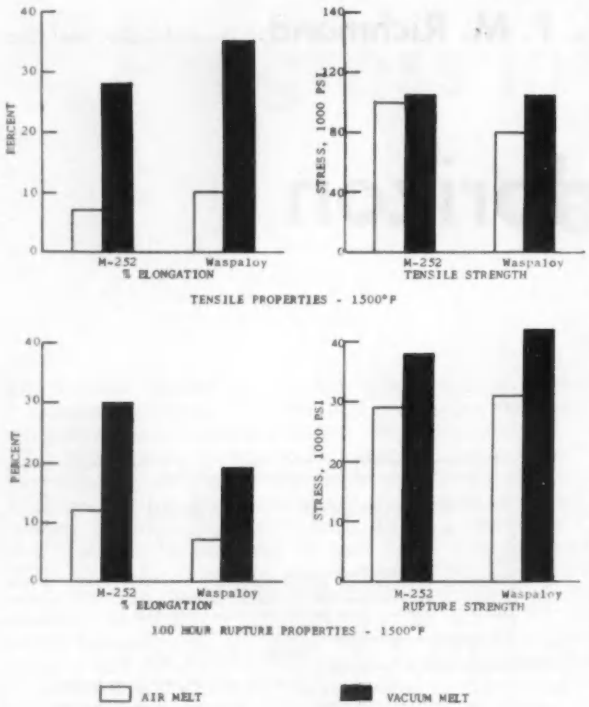


Fig. 3—Effect of vacuum melting (incorporating beneficial modifications in chemistry) on properties of two nickel-base super alloys.

ture strength, and ductility of air and vacuum melted material are compared. These results are based on average values for these alloys as melted in air and vacuum.

Fig. 4 illustrates the increase in stress-rupture specifications for Waspaloy as a result of vacuum melting and chemistry modifications. The first specification for air-melt Waspaloy required a rupture life of 23 hr at 1500 F and 27,500 psi. After considerable experience, this stress level was increased to 32,500 psi. There was no ductility requirement in the air-melt specification. First vacuum-melting efforts made it possible to increase this specification to 40 hr at 1500 F and 37,500 psi and to incorporate a minimum elongation of 5%. Later on, the stress was increased to 40,000 psi, the rupture life to 55 hr, and the elongation to 10%, and still more recently, primarily as a result of controlled boron and zirconium additions, the rupture life under these same conditions of 1500 F and 40,000 psi has been increased to 75 hr.

Importance of Grain Size

Tensile and rupture properties of super alloys intended for bucket materials are generally based on fabrication and heat-treatment practices which have been tailored to produce the best composition of tensile strength, rupture strength, and ductility. Variations in either forging practice or heat-treatment can be used to emphasize any of these properties at any given temperature. Grain size, for instance, can be controlled quite easily to maximize either high- or low-temperature properties. At temperatures below 1350 F, optimum tensile properties can be obtained with a fine grain size, whereas at higher temperatures or for longer times as in rupture tests, larger grain size is an advantage.

Fabrication and heat-treatment also play an important role in determining the combination of rupture life and ductility produced in these materials, as shown in Fig. 5, where ductility and rupture life are plotted schematically to show the usual inverse relationship. The right side of this diagram illustrates the effect of increasing solution temperature and grain size in increasing rupture life and decreasing ductility. Increasing amounts of cold work or hot cold work prior to solution treatment appears to lower the ductility for a given rupture life as indicated by the arrow pointing downward in the center of this figure.

This diagram also can be used in an attempt to explain the higher rupture strengths of vacuum-melted alloys by considering the major effect to be one of increased ductility. As shown at the left-hand portion of this figure, increased incongruous or hardening additions can increase the rupture life but generally result in a rapid decrease in rupture ductility. Vacuum melting without changes in chemistry can be considered to increase the rupture ductility with a minor improvement in rupture life.

At this higher ductility level, it is possible to incorporate increased alloy content and obtain a net result of both increased rupture life and ductility. Boron and zirconium are elements which appear to have the facility for accomplishing this. Use of these elements results in still higher rupture life and ductility than possible with vacuum melting and increased hardening additions alone.

Table 2 gives the temperature ratings based on 100-hr rupture life at 20,000 psi (from parameter plots) for the vacuum-melted materials studied in this investigation. Comparing these values with the chronological plot of Fig. 6 (temperature ratings of bucket alloys used in aircraft turbines since advent of turbosupercharger in 1918) illustrates the upturn in temperature rating due to vacuum melting and chemistry modifications. These properties indicate what can be expected in the next few years.

Forged nickel- or cobalt-base alloys quite possibly can be developed that will have a 100-hr rupture life of 20,000 psi at temperatures approaching 1800 F. This would now appear to be the ultimate attainable in these systems, and further increases in service temperatures of jet engines will undoubtedly require the use of refractory metals such as molybdenum for critical bucket application. When this occurs, the overall increase in engine temperatures will dictate the use of nickel- and cobalt-base alloys as turbine wheel (or even compressor wheel) materials. Moreover, the new fields of ram-jet and rocketing will undoubtedly find many uses for these alloys in sheet form. Thus, vacuum melting apparently is here to stay.

(Paper, "High-Temperature Properties of Vacuum-Melted Super Alloys," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

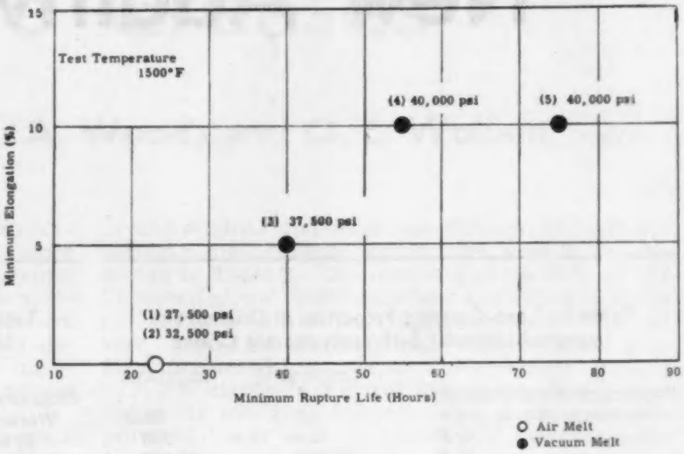


Fig. 4—Increase in stress-rupture specifications for Waspaloy super alloy as a result of vacuum melting and chemistry modifications.

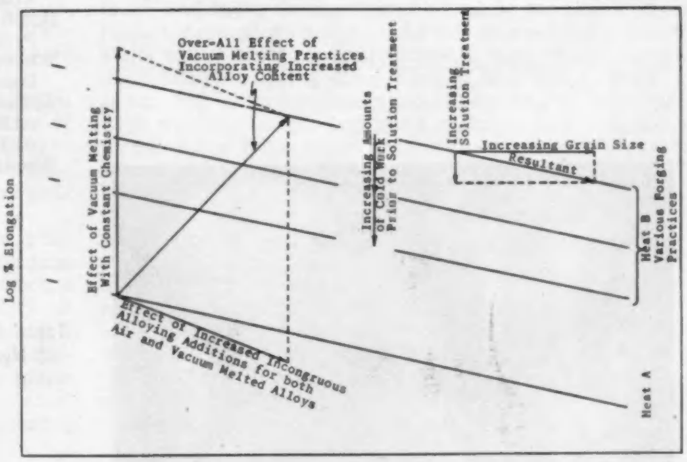


Fig. 5—Effects of melting practice, composition, solution treatment, and fabrication practice on a commercial super alloy at constant test temperature and stress.

Table 2—Temperature Ratings of Vacuum-Melted Alloys Based on 100-Hr Rupture Life at 20,000 Psi

	Temperature Rating,[a] F	
	Air Melted[b]	Vacuum Melted
J-1570	——	1650
GMR-235	1640	1670
Udimet 500	——	1670
M-252	1570	1625
Waspaloy	1570	1630

[a] Based on parameter plots of rupture data.
[b] Air-melt rupture data sources:
GMR-235—**Materials & Methods**, March 1957.
M-252 and Waspaloy—ASTM STP No. 170 (1955), "Compilation of Chemical Compositions and Rupture Strengths of Superstrength Alloys."

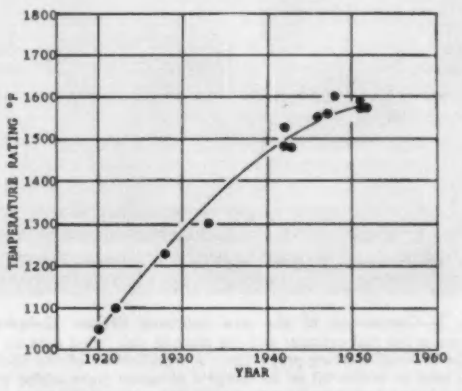


Fig. 6—Chronological increase in temperature ratings of bucket alloys (100-hr life at 20,000 psi) used in aircraft turbines since advent of turbosupercharger.

New Additives Improve

Table 1—Load-Carrying Properties of Original and Improved Lithium 12-Hydroxystearate Grease

	Original	Improved
Properties of Oil Content:		
Viscosity, SUS at 210 F	62	78.2
100 F	725	958
32 F	30,000	26,000
Viscosity Index	35	74
Timken EP Test:		
Pass, lb	10	12.5
Fail, lb	12.5	15

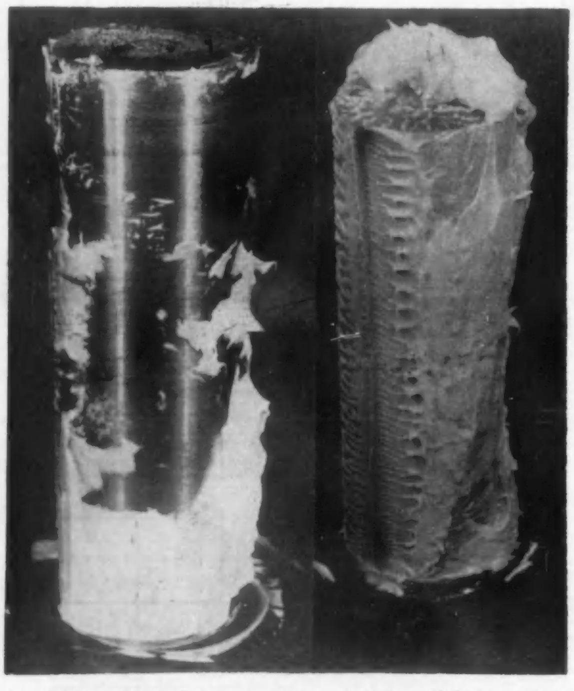


Fig. 1—Comparison of the new improved lithium 12-hydroxystearate grease in the test cylinder and the mixture was rolled with an 11-lb steel made in metal-wetting properties. A modification of the Shell Roll Test was used in which 10 ml increments of water were added to 100 g of grease in the test cylinder and the mixture was rolled with an 11-lb steel roller for 30 min. The cycle was repeated until the grease became saturated. The grease consistency was then determined and the tendency to wet metal was observed.

Table 2—Pertinent Characteristics of Original and Improved Lithium 12-Hydroxystearate Grease

	Original	Improved
Characteristics:		
Worked Penetration		
60 Strokes	285	276
100,000 Strokes	316	311
Shell Roll Test, micropen:		
Original	125	116
After 24 Hr at Room Temperature	185	162
After 24 Hr at 212 F	196	181
Bomb Oxidation:		
Pressure Drop at 100 Hr, psi	5	5
Wheel Bearing Test, 440 rpm:		
Loss, 6 Hr at 275 F, g	0.1	0.0
Apparent Viscosity at 32 F:		
At 25 Sec^{-1}, poises	630	776
At 100 Sec^{-1}	120	156
Bleeding, 50 Hr at 212 F, %w	6.3	2.2

Table 3—Pertinent Characteristics of Improved Lithium 12-Hydroxystearate Grease and Microgel Multipurpose Automotive Grease

	Improved Lithium 12-Hydroxy-stearate Grease	Microgel Multipurpose Automotive Grease
Characteristics:		
Dropping Point, F	346	Does not melt
Worked Penetration,		
60 strokes	276	287
100,000 strokes	311	316
Shell Roll Test, micropen:		
Original	116	127
After 24 Hr at Room Temperature	162	151
After 24 Hr at 212 F	181	156
Water Washout at 100 F, %	4.7	0.4
Glass Jar Bearing Corrosion	None	None
Bleeding, 50 Hr at 212 F, %	2.2	1.0
Bomb Oxidation:		
Pressure Drop at 100 Hr, psi	5	8
Wheel Bearing Test, 440 rpm		
Loss, 6 Hr at 275 F, g	0.0	0.0
Metal Affinity Test:		
Saturated at, % H_2O	70	50
Affinity for Metal	Excellent	Excellent
Consistency, micropen	181	71

Multipurpose Greases

Based on paper by **H. A. Woods and O. E. Wollam,** Shell Oil Co.

RECENT improvements in the lithium 12-hydroxystearate multipurpose greases include: more complete metal wetting, better protection against corrosion in the presence of free water, and a moderate increase in load-carrying properties. Future multipurpose automotive greases will probably extend the high-temperature ceiling with new high-melting organic and nonmelting inorganic grease thickeners responsible for the improvement.

Experience with the lithium 12-hydroxystearate multipurpose greases revealed a need for certain improvements. For example, the water resistance of these greases was so great that metal wetting in the presence of water was often inadequate, and as a result lubrication sometimes suffered. Likewise, it was found that corrosion protection in the presence of free water was not as good as that provided by conventional soap-base greases.

Through the use of suitable additives, good metal wetting and corrosion protection in the presence of water were incorporated in the lithium 12-hydroxystearate greases, without reducing the multipurpose characteristics. An indication of the improvements is shown in Figs. 1 and 2.

In addition to metal wetting and corrosion protection, a moderate improvement in load-carrying properties was achieved through the use of a more viscous oil. This was accomplished at essentially no decrease in low-temperature properties by using a blend of 30 V.I. and 90 V.I. oils, coupled with improved grease processing. The improvement made is shown in Table 1.

A comparison of other pertinent characteristics of the original and improved lithium 12-hydroxystearate multipurpose automotive grease is presented in Table 2. The mechanical stability of the improved grease is still excellent as evaluated in the ASTM 100,000 stroke penetration test and Shell roll test. Oxidation stability and wheel bearing performance are also excellent. The apparent viscosity at 32 F is slightly higher but still insures good pumpability at low temperatures. An unexpected improvement was made in bleeding at elevated temperatures.

Future Trends

Looking into the future we visualize many interesting changes in multipurpose greases. For one, more and more demands will be made to extend the high-temperature ceiling. As this has not been possible using existing multipurpose-type soaps, new high-temperature gelling agents are being developed. For example, Standard Oil Co. of Ind. reports high melting points and good multipurpose characteristics for both their aryl urea-thickened grease and their grease thickened with diamidocarbonyl (DAC) fibers. Likewise, Standard Oil Co. of Calif. mentions similar properties for a recently introduced grease which employs a new organic thickener, sodium octadecyl terephthalamate. Several inorganic grease thickeners also have become available commercially, such as du Pont's Estersil, a waterproof silica gel, and National Lead's Bentone 34 which is dimethyldioctadecyl ammonium bentonite. The latter two gelling agents emphasize the absence of melting point.

Shell is interested in the inorganic microgel-type

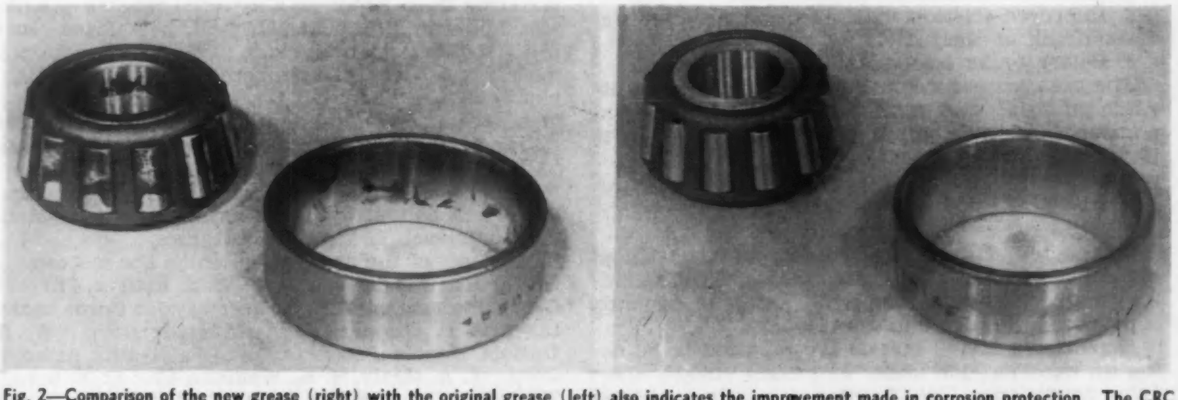


Fig. 2—Comparison of the new grease (right) with the original grease (left) also indicates the improvement made in corrosion protection. The CRC Method L-4 glass jar bearing corrosion test was used. The bearings were packed with grease and rotated for 1 min at 1750 rpm to distribute the grease. The bearings were then placed on a tapered glass fixture, completely submersed in distilled water, and placed in an 8-oz glass jar that contained 5 ml of distilled water. The jars were sealed and stored at 77 F for 2 weeks. This is a very severe test that has been found to correlate well with wheel bearing service.

thickeners, because of their thermal and oxidation stability and the absence of melting point. Pertinent properties of the multipurpose automotive version of the microgel grease are shown in Table 3 and compared with similar data obtained with the improved lithium 12-hydroxystearate grease. Note that the microgel grease retains all of the multipurpose characteristics of the lithium 12-hydroxystearate grease and has the additional advantage of being nonmelting. Mechanical stability, water resistance, corrosion protection, tendency to bleed, oxidation stability, wheel bearing performance, and metal wetting properties are all good. The absence of dropping point is important as it provides added protection in heavy-duty wheel bearing service, where high temperatures may cause slumping and grease leakage with soap-base greases.

(Paper, "Multipurpose Greases—Lagging Applications," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Organic Friction Materials . . .

. . . are doing a good job on trucks and buses, but if greater demands are placed on them, non-organic materials may become essential.

Based on secretary's report by **W. T. Birge,** Chrysler Corp.

ORGANICALLY bonded, asbestos fiber friction materials are keeping pace with requirements even on medium weight trucks where horsepower and gvw ratings have risen without a comparable change in the foundation brake. Since 1953, the average horsepower of three competing vehicles in this class has risen 29% with only a 3% increase in braking area. Yet the wheels can still be slid if the trucks are reasonably operated and maintained.

Truck manufacturers are relying too much on friction materials. Too often a change is made in lining when the foundation brake should be scrutinized. This is also true with clutches. The tendency is to increase spring pressure rather than facing size when horsepower is increased.

Selecting the friction material to fit the type of service has noticeably improved performance and endurance on all types of buses. Today's buses carry 35% more weight than they did in 1947, and horsepower and speeds have increased, but the linings are giving longer life with safer and surer stops. This is attributable to:

1. Improved maintenance practices.
2. Improved friction materials and a better understanding of their use.
3. Better brake component parts.

The prospect is for continued development of organic materials and work in the field of high-temperature binders to obtain more fade-resistant friction materials.

Sintered Metallics

Compacted, sintered, powdered metals without organic binders and therefore capable of withstanding high operating temperatures, have recently come to the fore for buses and trucks.

Iron-base sintered metals are reported to be doing an excellent job under extremely rugged operating conditions. Use of sintered-iron brake blocks in a West Coast logging operation, for example, has eliminated the need for continuous water cooling of the brake drums and has greatly increased drum life.

Heat-checking and burning of brake drums is less of a problem with metallics, which have little insulating value, and drum filament temperatures are kept at a minimum. At the same time, this characteristic can be a problem because more heat is allowed to enter the brake. It could cause premature brake fluid boiling and damage to rubber parts. Basic brake design should be reconsidered to make full use of this material.

Success with sintered metallic friction materials hinges on three factors:

1. Proper material selection.
2. The right use, where installation and adjustment are of particular importance.
3. Correct design. Clutch or brake design originally based on organic materials may require redesign to gain full advantage of the sintered metallics.

Sintered Ceramic-Metallics

Combining ceramic and metallic powders, then sintering them, produces a material capable of withstanding very high heat. Over the past dozen years, great strides have been made in giving the ceramic-metallics a constant "temperature versus friction" characteristic. Limited truck brake dynamometer tests, using ceramic-metallic elements have been disappointing, but experience in aircraft brakes, and to some extent in industrial clutches, indicates many problems associated with high temperatures could best be met by use of extreme heat-resistant materials such as ceramic-metallics.

Members of the panel from which the material in this article was derived were: **W. R. Rodger,** Chrysler Corp., chairman; **W. T. Birge,** Chrysler Corp., secretary; **E. F. Cramer,** Johns-Manville Corp.; **W. H. DuBois,** Bendix Products Division, Bendix Aviation Corp.; **T. A. Healy,** S. K. Wellman Co.; **C. A. Schell,** Thermoid Co.; and **R. E Spokes,** American Brakeblok Division, American Brakeshoe Co

This abridgment is based on secretary's report of a round table entitled "Friction Materials for Trucks and Buses—Latest Developments."

Here Are the Answers To 5 Commonly Asked Questions on . . .

Computer-Controlled Machines

Based on secretary's report by **J. A. Banzhaf,** General Riveters, Inc.

Q. Can you give us a definition of computer control?

A. The term computer control is something of a misnomer. Programmed control of machines would be better as describing equipment where a number of different paths of operation are successfully programmed through a machine tool, a group of tools, or other manufacturing processes. We could also term it that bridge between the original design and the final finishing of a part, whereby information is fed into a means of data retention in the form of a punch card, punch tape, or magnetic tape, thus bypassing physical equipment such as jigs and templates, to produce a completed piece.

Q. What types of computer control exist?

A. Two specific types are now in use—point-to-point positioning and continuous path control. The former is used for programming drilling, punching, riveting, spot welding, and like processes; the latter for dictating to milling machines and similar equipment. Point-to-point positioning is considered less difficult since any path and speed can be used to get to the next point, the governing factor being the basic economics involved in accomplishing the maneuver. In continuous machining control, speed, and feed are, of course, factors, together with accurate accounting for the direction of movement.

Q. Is it true that computer-controlled machines are economically justifiable only with high-volume production?

A. No, quite the contrary. Once computer-controlled equipment is available for a given type of work, any job within its capacity generally can be programmed at considerably less cost than conventional methods of tooling regardless of the length of the production run. In most instances, programming can be altered readily to suit minor engineering changes or continuous improvements as they occur. That is not often so in jig-and-fixture-type manufacture.

Q. Can standard machines be converted to computer control?

A. The success of conversion depends primarily on economics. Many computer-controlled machines in use today for testing, experimentation and production were originally standard equipment. However, the advisability of such a conversion is highly debatable because of the extreme rework or, in

THE INFORMATION presented in this article was contributed by these seven men at the panel on Computer Control of Machines at an SAE National Production Forum:

T. H. Speller, General Riveters, Inc., chairman

J. A. Banzhaf, General Riveters, Inc., secretary

John Fondrk, Stromberg Carlson Corp.

Robert Gregory, Massachusetts Institute of Technology

David Laughlin, Giddings & Lewis Machine Tool Co.

John Morin, Concord Control, Inc.

George Schwab, Ryan Aeronautical Co.

many cases, complete rebuilding of lead screw systems and gear trains to give special needs and backlash conditions, and the attention which must be given to the gibs and ways to eliminate or, at least control, stick-slip friction problems. In such conversions virtually all that remains in the end is the basic "cast iron" of the original equipment.

Extreme sensitivity must be built into all elements of a programmed machine tool. For this reason it is impractical to attempt to drive an old machine with the servo systems involved in this specialized field.

Q. How are machine and work-piece deflections compensated for in computer-controlled equipment?

A. The programming of an operation, particularly in continuous path control such as milling, is calculated on the basis of the cutter path "through air." When actual chips are being cut, machine and/or work-piece deflections might possibly introduce inaccuracy or chatter. Occasionally, therefore, it is necessary to compensate by reprogramming. This is not as costly as it might seem since, generally, it is unnecessary to reprogram the entire job, but only the specific sections where the problem exists. It is accomplished with existing tape and card controls. Admittedly, such corrections are made to a degree on a trial and error method.

In instances where the art has progressed such problems are being preconsidered, and in more elaborate equipment where cost is a lesser issue, self-compensating servo systems can be applied. Such methods sometimes include programming automatic inspection as part of the overall system. By and large, the prohibitive costs and the inherent troublesome nature of the complex electrical controls required to accomplish this, rule it out of the practical area of industry.

(This abridgment is based on a secretary's report of an SAE production panel entitled "Computer Control of Machines." The complete report, along with reports of four other production panels, is available from SAE Special Publications, 485 Lexington Ave., New York 17, N.Y., as SP-318. Price: $1.50 to members; 3.00 to nonmembers.)

Catching a Jet Transport . . .

. . . to prevent overrun of a short runway can be accomplished in six different ways. And there are at least two ways of stopping it, once it's caught.

Based on a paper by **Charles J. Daniels,** All American Engineering Co.

STOPPING commercial jet airliners may require safety overrun arresters on runways, present military experience indicates. Such arresters are especially needed on short runways when there is no safe overrun area.

The problem is simpler than aircraft carrier landings since extreme decelerations are not needed. The two solutions needed are a ground arresting mechanism and an aircraft attachment point.

Catching the Airplane

Six systems that could be used to grab an overshoot-airplane are:

- **Tail hook**—Aircraft carrier development and

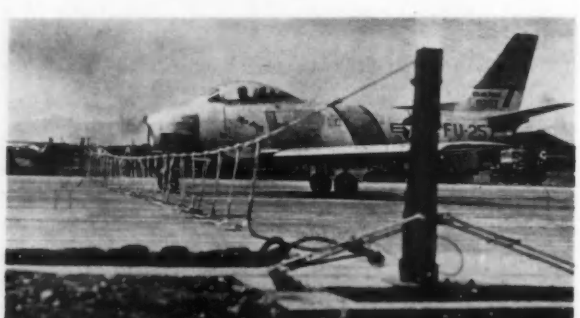


Fig. 1—Plane striking net flips the ground cable in front of the main landing gear. The net trails with the plane.

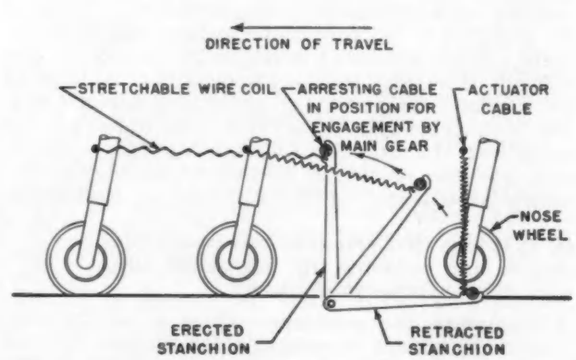


Fig. 2—Nose wheel catches a spring wire. The wire pulls an arm which lifts the cable to engage the main wheels. The wire shears and stays with the plane.

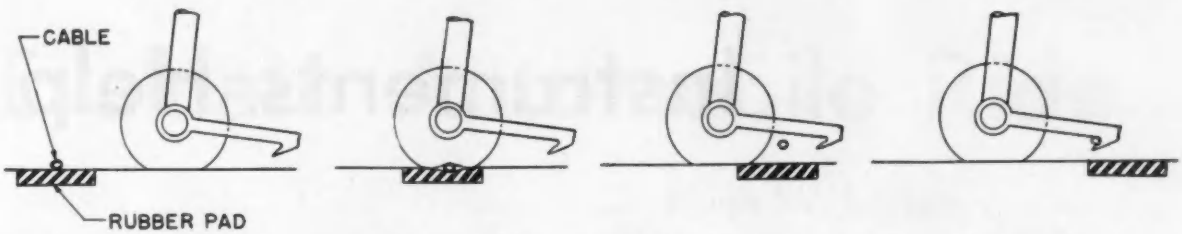


Fig. 3—Aircraft wheel pushes arresting cable into rubber mat. After wheel passes, cable snaps up and is caught by hook on wheel.

experience make this device efficient and simple. The weight penalty to a commercial liner would probably exceed 0.3% of the gross aircraft weight as excess structural strength must be built into the airplane.

• **Net pop-up**—A nylon net is stretched across the runway with the arresting cable lying on the ground and lightly attached to the net. When the aircraft rams the net the cable is snapped up to engage the wheel struts. The net is torn loose and stays with the airplane. Little or no extra airplane weight is needed but the system will not work with some airplane configurations. (See Fig. 1)

• **Compressed air pop-up**—Compressed air throws the arresting cable up after the nose wheel passes. Again, there is no excess aircraft weight, but the mechanism is complicated and needs constant attention for good performance.

• **Cable stanchion erector**—The nose wheel hits a high-strung stretchable wire. The wire pulls a lever arm which lifts the arresting cable in front of the main wheel struts. The trigger wire shears off and trails with the airplane. (See Fig. 2)

• **Wheel pop-up**—The wheels run over the arresting cable and push it into a rubber mat. The cable springs up and catches in a hook behind the wheel. (See Fig. 3.) Some weight would be added to the airplane but not as much as with a tail hook.

• **Wheel scoop-up**—A "cow catcher" in front of the wheels lifts the cable until it engages the wheel strut. The arresting cable has to be elevated to provide ground clearance for the scoop. (See Fig. 4.)

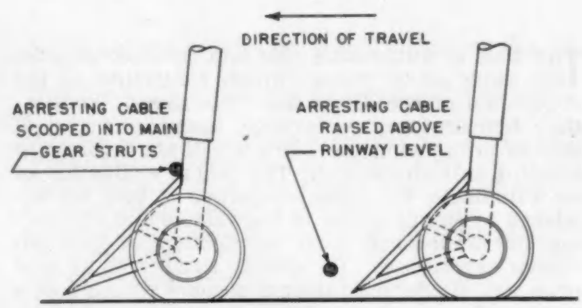


Fig. 4—Scoop on front of wheel lifts cable to wheel strut. Cable must be elevated above ground clearance of scoop.

Stopping the Airplane

Commercial installations of arresting engines will probably require easy maintenance, reliability, all-weather operation, flush-to-ground installation, quick resetting, variable capacity, smooth deceleration characteristics, and remote control from the tower.

The simplest system would be a chain laid along the sides of the runway. The airplane catches and drags more and more chain until it stops. The main drawbacks are the weight of the chain—greater than the airplane weight—and the difficulty in resetting.

A "water squeezer" has been used to stop airplanes. (See Fig. 5.) It stops the aircraft by pulling a piston through a tube filled with water. The tube diameter is shaped to give deceleration characteristics matched to the airplane requirements.

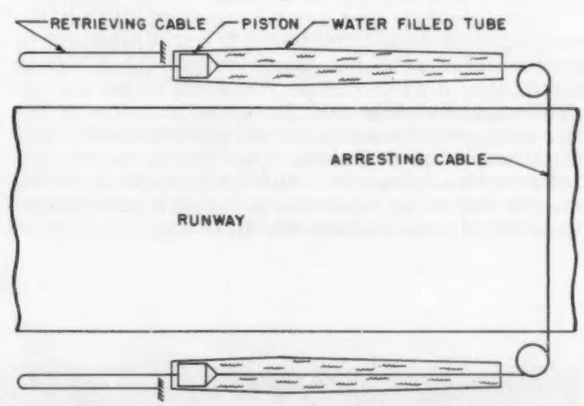


Fig. 5—Piston dragged through tube of water stops airplane attached to arresting cable. Tube diameter is shaped to give required deceleration.

It can be buried and works with antifreeze for cold-weather operation.

Resetting requires a truck to pull the piston retrieving cable and takes about 15 min. Present designs will stop a 300,000-lb aircraft in 1000 ft from 120 knots.

(Paper, "Overrun Safety Arrestment of Commercial Jet Aircraft," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Instruments Help

THE field of automobile ride and comfort includes the study of all things which contribute to the impression of the driver and passengers. Ventilation, temperature, appearance, sound, and feel of the car are some of the items which are involved in creating this impression. The overall evaluation of an automobile for these properties is best accomplished by simply riding in the vehicle and comparing the impression with recollection of previous similar experiences. On specific items such as road noise and shake, instruments become valuable as a means of evaluation. More importantly, instruments are valuable as a means of understanding the nature of such phenomena. Having an understanding of the mechanism of such disturbances, a means of control can usually be devised.

In vehicle ride and comfort testing, the instrumentation is usually limited to the measurement of motion, force, or sound. Some very adequate, simple mechanical devices can be employed under certain circumstances; however, the great majority of instrumentation today involves electroacoustic and electromechanical transducers. Strain gages, potentiometers, magnetic reluctance bridges, piezoelectric elements, capacitance elements, differential transformers, and others are all devices which generate a voltage or change electrical impedance as a function of displacement. A coil and magnet are used commonly to generate a voltage proportional to relative velocity. Microphones and pressure pickups operate because a diaphragm moves under the influence of air pressure, and the displacement or velocity of the diaphragm is detected. Acceleration is observed by detecting the displacement of a mass supported on a stiff spring. The most common oscillatory quantities which must be observed in ride and comfort testing are: sound pressure, acceleration, velocity, displacement, rate of change of acceleration, torque, force, and strain.

With the recent advances in electronics, all sorts of recording devices are available. The choice of recording device is influenced by such factors as portability, convenience of operation, reliability, accuracy, and the form in which the data is needed. In some cases a meter reading is sufficient. Multichannel oscillographs will record simultaneously instantaneous voltages from several transducers following variations that occur several thousand times a second. Magnetic storage of data on tape is often desirable in order that it can be reproduced later in electrical form for automatic data reduction. In the case of acoustic measurements the sound may

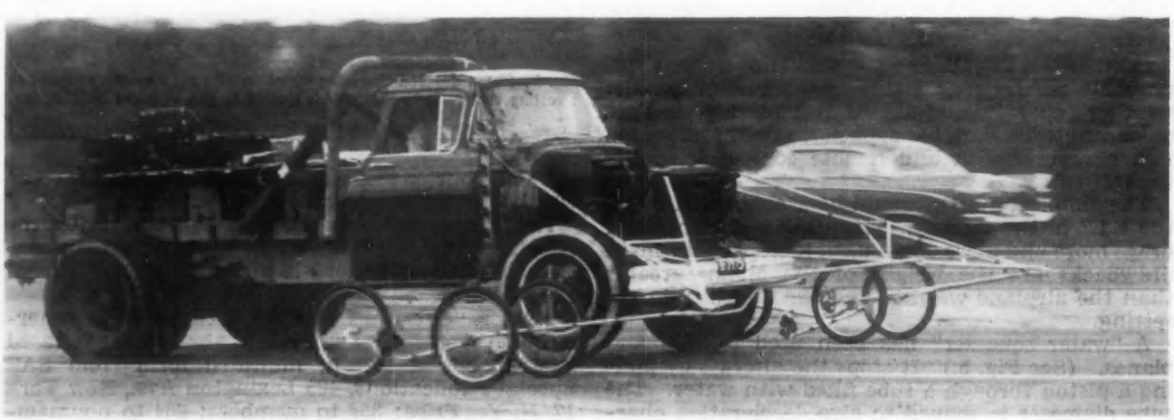


Fig. 1—Truck with camera sulkies and oscillographic equipment for front suspension study.

Evaluate Automobile Ride

Excerpts from paper by **Hugh W. Larsen,** General Motors Corp.

be reproduced, of course. Ordinarily, several different types of transducers will be used simultaneously.

Occasionally it is desirable to simultaneously use more than one recording device. An example of this was a truck suspension study in which it was necessary to observe simultaneously many motions and forces in the suspension system. A recording oscillograph with appropriate amplifiers was used for obtaining all force and certain motional data while a pair of high-speed movie cameras was used to record the motion of the wheels with particular interest in wheel rotation and contact of the tire with the road surface (Fig. 1). A common time base between the oscillograph and the cameras was provided by photographing a neon lamp which was flashed with current supplied through a galvanometer. It was necessary to obtain simultaneously instantaneous values of the following quantities during 3 sec of transient operation:

Rearward tangential moment at ground (right and left).
Brake torque (right and left).
Moment about kingpin due to tie rod force.
Moment about kingpin due to drag link force.
Wheel angular acceleration (right and left).
Wheel spindle to ground acceleration (right and left).
Steering angle acceleration—Right and left kingpin.
Transverse axle to frame acceleration.
Wheel angular velocity (right and left).
Wheel spindle to ground velocity (right and left).
Steering angle—Right and left kingpin.
Steering angle velocity—Right and left kingpin.
Transverse axle to frame velocity.
Wheel vertical position relative to ground (right and left).
Transverse axle to frame displacement.
Wheel vertical position relative to frame (right and left).
Frame vertical position relative to ground (right and left).
Axle angle with respect to frame (right and left).
Steering wheel angle.
Tire compression (right and left).

The number of separate items of data required in this project demonstrates the necessity for extreme reliability in instrumentation. If only one transducer and recording channel is used, an occasional failure of the system is usually of no consequence. However, when many transducers and many re-

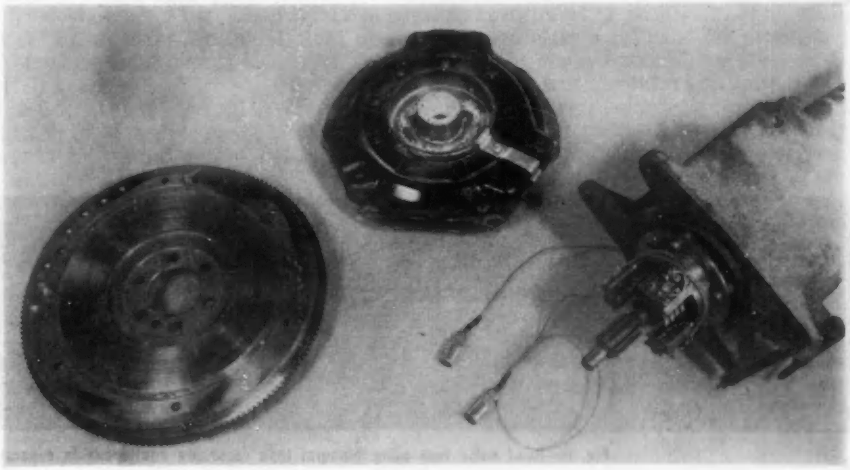


Fig. 2—Barium titanate accelerometers mounted on flywheel and slipring components for measurement of fore-and-aft oscillation of flywheel periphery.

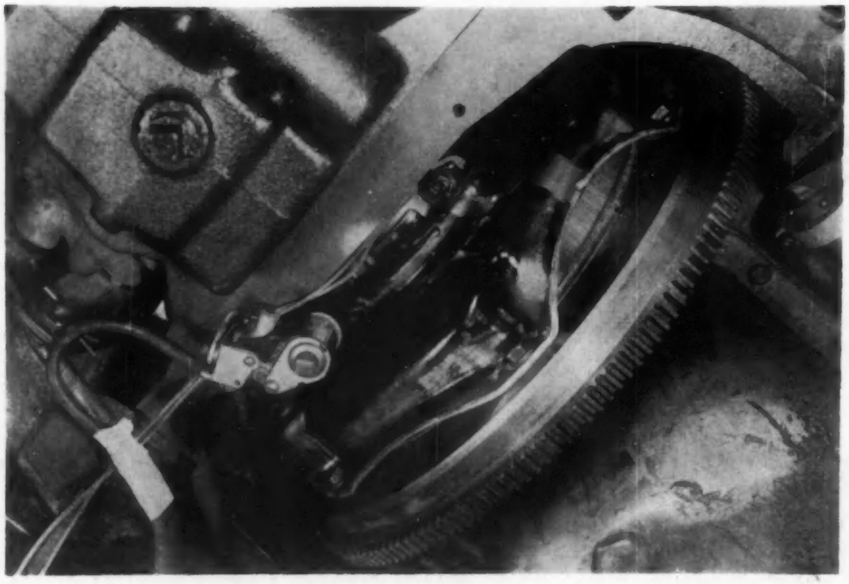


Fig. 3—Items of Fig. 2 assembled in vehicle for operation on chassis dynamometer. Accelerometers are concealed by clutch cover.

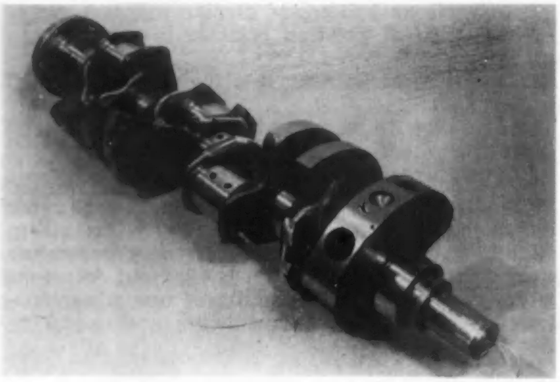


Fig. 4—Wired engine crank with torque sensitive strain gage bridge inside rear main journal.

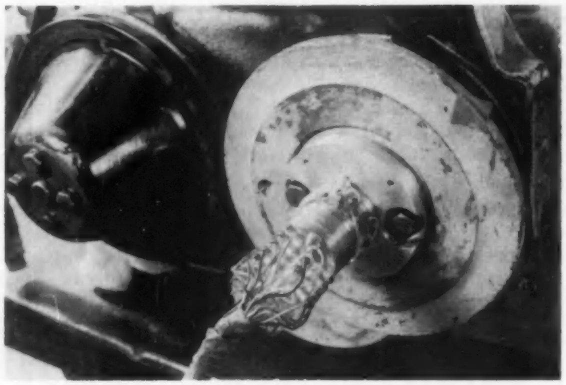


Fig. 5—Multicircuit package slipring and brush assembly on front of wired engine crank.

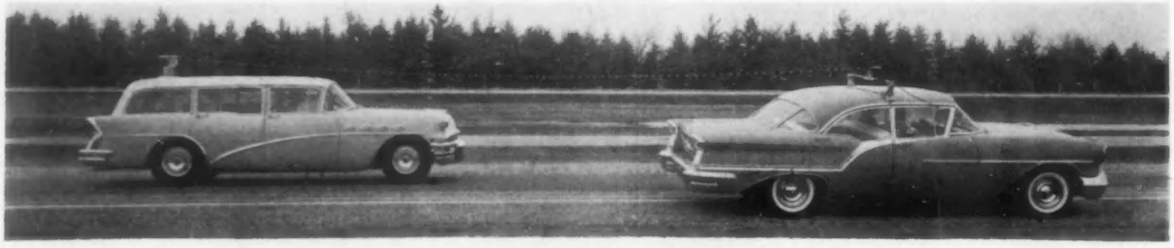


Fig. 6—Road noise test using binaural tape recording equipment in separate vehicle.

cording channels are used simultaneously, a high degree of reliability of each channel is essential.

Occasionally the connection between the transducer and the recording or indicating device is somewhat awkward as in the case of rotating shafting or in mobile situations in which the recording instruments are not carried in the test car. Figs. 2 and 3 show commercially available barium titanate accelerometers mounted on an engine flywheel for the purpose of detecting fore-and-aft motion of the flywheel during normal operation of the engine. In this case, a quick, inexpensive, and adequate slipring has been built into the clutch assembly by molding brass rings in Epoxy resin. It is interesting that at an engine speed of 4000 rpm the transverse force-field experienced by the accelerometer is approximately 400 g per in. of radius or, in the case of a pickup located at a radius, as shown in Fig. 2, the force-field exceeds 2000 g. Not all transducers will give reliable results under such circumstances. Observations of the fore-and-aft acceleration of the flywheel periphery contributed materially to the understanding of the mechanism of a severe vibration period and subsequent elimination of the disturbance by minor modification of the vehicle.

It is unfortunate that the power from piston engines comes in pulses which, if the vehicle propulsion system is not properly arranged, will cause severe noise and vibration. With the current trend in engine design these pulses are becoming more difficult to control. To permit computer analysis of driveline vibration it becomes necessary to determine, among other things, the magnitude of the torque pulses delivered to the flywheel by the engine. There are, perhaps, several means of accomplishing this; however, in our case it was necessary that the vehicle operate in a normal fashion in order that simultaneous observations of engine torque pulses, driveline torsional oscillation, and noise in the body could be observed.

The rear main journal of the crank was hollowed out to provide a tubular section with space inside sufficient for strain gages. The wall thickness of the tubular section was estimated to provide suitable stress levels. The torque-sensitive strain-gage bridge was calibrated directly in terms of torque. Signal leads were carried through the crankshaft to the front of the engine as shown in Fig. 4. Running the wires through the crankshaft permits the use of a package slipring such as shown in Fig. 5. It is often much simpler to wire a crank than it is to build special ring and brush assemblies in clutches and transmissions.

Quantitative computer solution of the equations of motion of the vehicle propulsion system provided design parameters which result in minimum driveline disturbance. These parameters were incorporated in a driveline revision and found to be satisfactory. It is interesting that in this program evaluation was done by ear and instruments were used only to aid in understanding the mechanism involved.

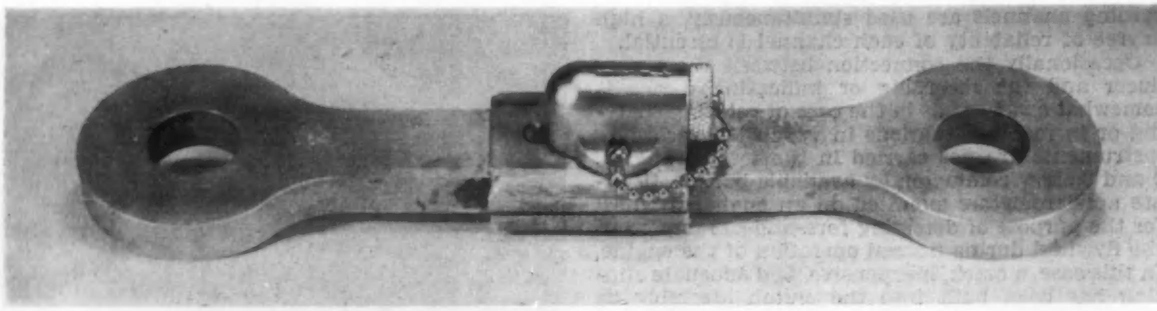
Figs. 6 and 7 show a station wagon equipped for recording. This is a rather specialized facility used for binaural tape recording of sounds in vehicles during normal road operation. The recordings are later played back to a jury for comparative evaluation. The station wagon contains a dual-track tape recorder, a power supply, and a cable reel mechanism which avoids the use of sliprings. A considerable saving in test time as well as improved accuracies have resulted from using this separate vehicle rather than placing the recording equipment in the vehicle under test. The cable reel mechanism permits the distance between the cars to vary by 50 ft.

Fig. 7—Interior view of recording station wagon. Cable device is housed at right and power supply is in tire well.

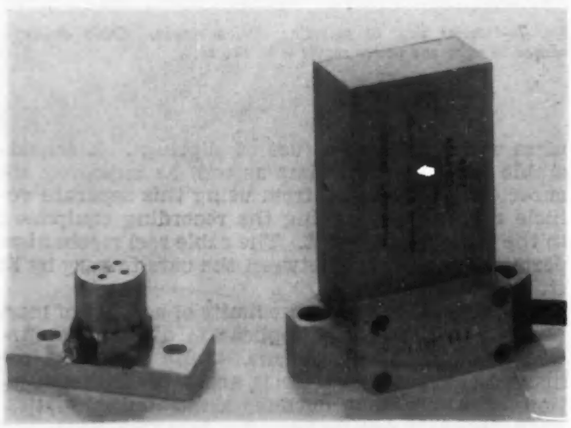
It is difficult to define the limits of activity of most people engaged in the application of instrumentation to automotive problems. Quite ordinarily the instrumentation engineer is active in the conception of a program outline, associated analytical work, the data acquisition, the data reduction, and subsequent data interpretation. It is necessary that the instrumentation engineer be familiar with the overall program inasmuch as he can best decide the type of data required and the best means of acquisition for the particular purpose at hand. This is the most difficult phase of instrumentation. The actual measuring procedures, although occasionally involved, are ordinarily accomplished in a direct fashion with eventual success a near certainty.

The success of a project is determined almost wholly in the early planning stages. Programs must be outlined on the basis of what is required and not what is measured most easily. Experimental techniques are merely means of observation and do not replace analytical treatment of problems. The analytical program is sometimes difficult to recognize, but it always exists in some form. The trial-and-error program is a statistical solution in which the engineer assumes that some magical combination will make the vehicle ride or sound better. Even if the budget survives, cut-and-try methods lead to confusion and failure, should no solution exist, while a well-founded analytical program should lead directly to the conclusion that no solutions exist, and thus at least avoid the confusion. It is not always possible to arrive at a clear-cut analytical expression of a problem; however, the best analysis, though it may be only qualitative, should dictate the experimental procedures.

(Paper, "Instrument Application to Riding Comfort," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



DRAWBAR PULL measurements are made by a tension load link.

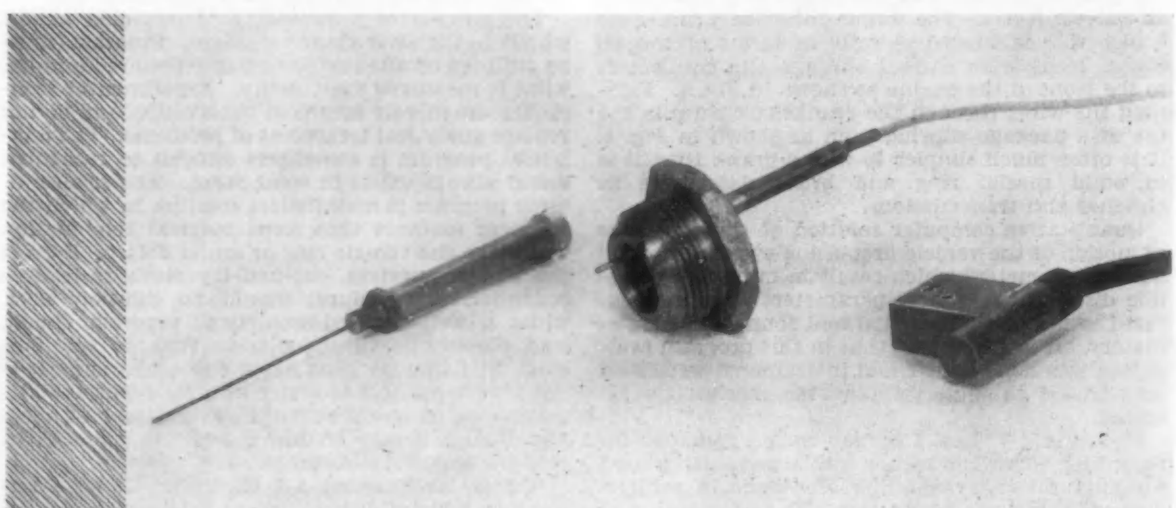


ACCELERATION of an object is transduced by either a strain gage or a piezo-crystal accelerometer. Both are spring and mass systems used at a frequency lower than the resonant frequency. Two commercially available accelerometers are shown.

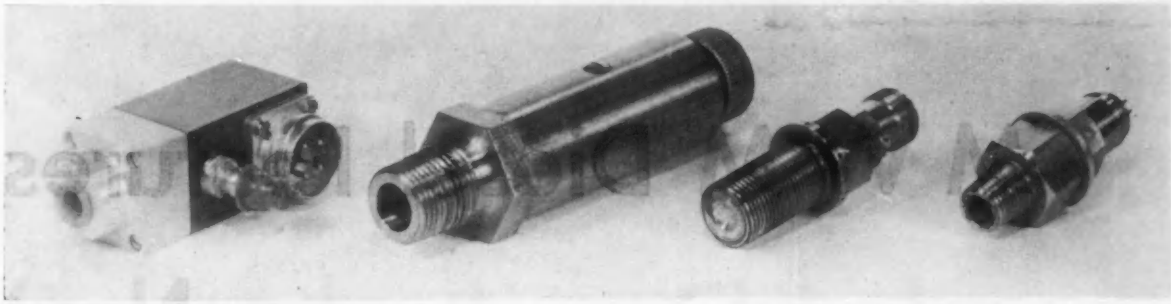
Sensing devices used in . . .

Mobile Testing

Based on paper by **W. D. Speight and W. H. Jones,** Caterpillar Tractor Co.



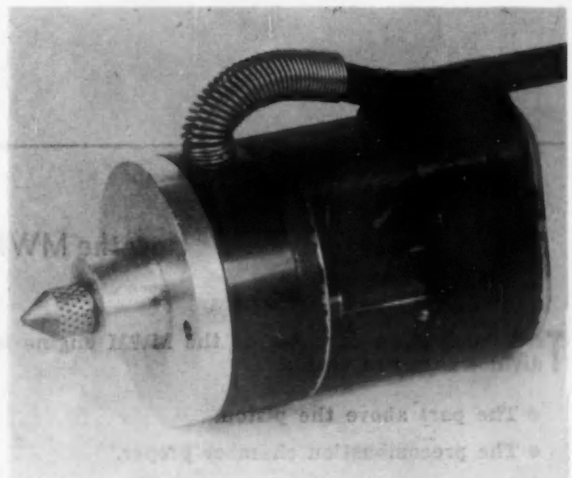
DYNAMIC DISPLACEMENT of moving parts is sensed by variable inductance devices using moving metal cores. These are similar to linear differential transformers.



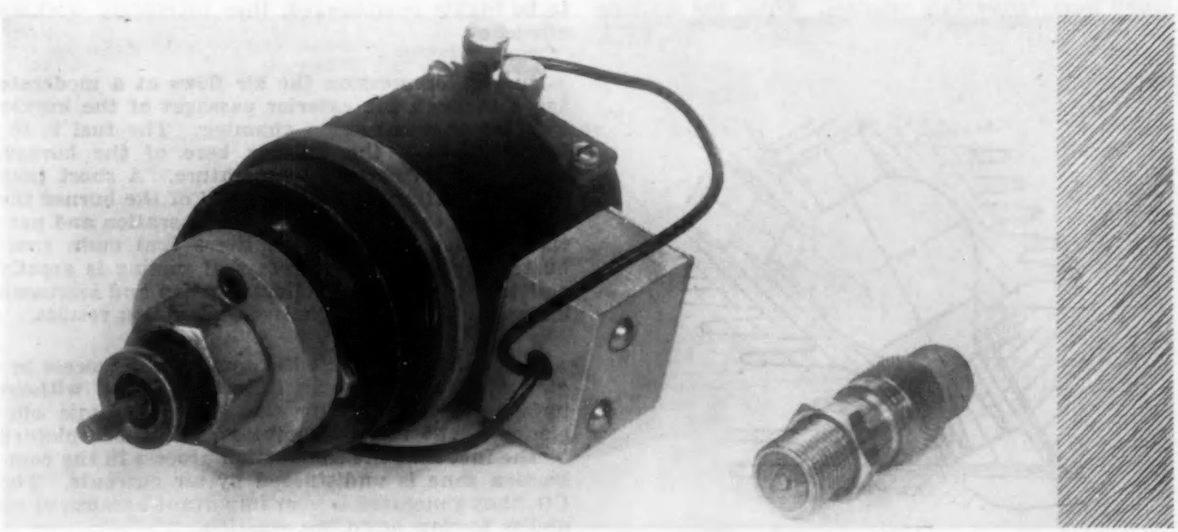
PRESSURE transducers measure liquid or gas pressure. Strain gages are used in the transducer constructions.

# of Earthmovers

Here are a number of sensing devices one earthmoving equipment company uses in the dynamic testing of their equipment. The sensing device signal is transferred by means of an amplifier or intermediate mechanism to recording or indicating devices which disclose the desired information.



VELOCITY of a part is sensed by a seismic self-generating, moving magnetic transducer.



ROTATIONAL VELOCITY can be recorded as the output of a d-c tachometer generator or can be obtained by counting electrical impulses which originate due to the interaction of a moving metallic part and the field of a magnetic pickup. These two types of velocity transducers are shown.

M W M Diesel Features

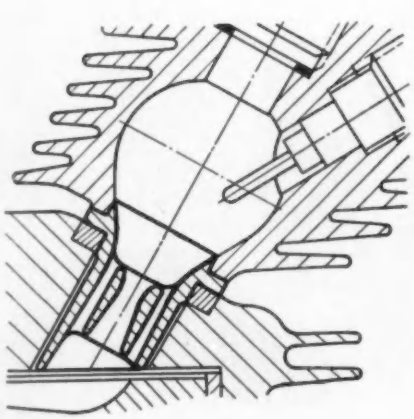
a New

How the MWM System Works

THE combustion chamber of the MWM engine is divided into two parts:

- The part above the piston.
- The precombustion chamber proper.

As shown in the accompanying illustration, the precombustion chamber is fitted in the cylinder head and connected to it only by a comparatively small heat-conducting conduit. Thus, the heating of the cylinder head is reduced to a minimum. The precombustion chamber is connected with the main combustion chamber by an inserted burner. The internal diameter of the burner is wide enough to avoid any appreciable choking or back pressure. The through flow passage of the burner is divided into interior and exterior parts, both proportionate to one another. This construction enables simple design of the cylinder head and the piston. The heat dissipation properties in the piston enable it to be highly overcharged, thus increasing working efficiency.



During compression the air flows at a moderate speed through the exterior passages of the burner into the precombustion chamber. The fuel is injected through the interior bore of the burner, which is at a certain temperature. A short time after contacting the interior wall of the burner the fuel undergoes a simultaneous evaporation and partial reaction, which starts the actual main combustion process. The process of mixing is greatly assisted by intensive fuel evaporation and increased diffusion. Almost smokeless combustion results.

It is noteworthy that the combustion process begins after a very short induction period without unfavorably influencing the thermodynamic efficiency or the fuel consumption. This is explained by the fact that the combustion process in the combustion zone is undisturbed by air currents. The CO_2 thus generated is very important because of its ability to slow down the reaction.

Excerpts from paper by **H. L. Hockel,** Motoren-Werke Mannheim AG, Germany

Precombustion Chamber

THE MWM balanced-pressure precombustion-chamber diesel engine is noted for its:

1. Smooth combustion and low combustion noise.
2. Ability to use a variety of fuels.
3. Excellent cold-starting characteristics.

Combustion Is Smooth

The extremely smooth combustion process is directly related to the low rate of pressure rise occurring with this system, as compared, say, with diesel engines fitted with the swirl chamber, or with direct injection.

The essential difference in combustion can best be

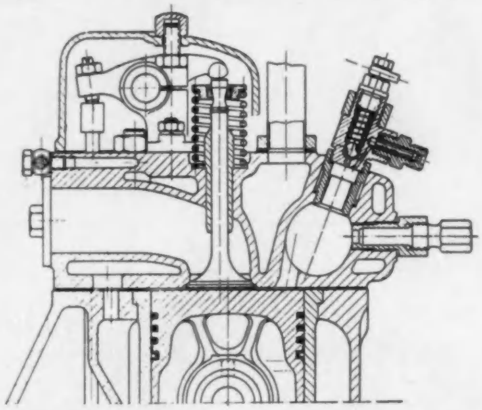


Fig. 1—Combustion chamber of watercooled swirl-chamber engine (*W*) type KD 12.

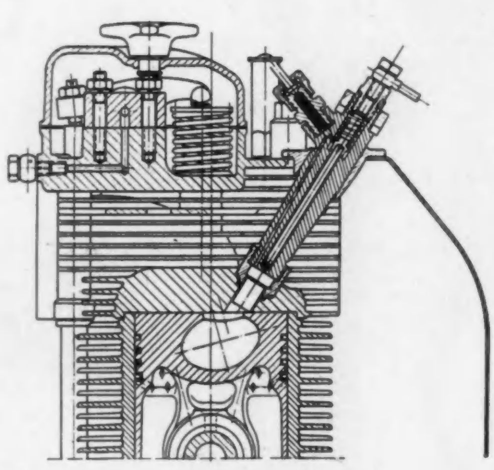


Fig. 2—Combustion chamber of aircooled diesel engine with direct fuel injection (*K*) type AKD 12.

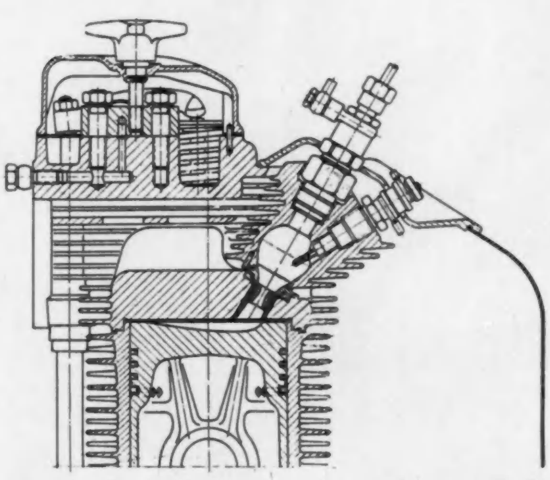


Fig. 3—Combustion chamber of aircooled diesel engine with MWM balanced-pressure precombustion chamber (*GV*).

demonstrated by examining the three different types of diesel engines. Data concerning each engine is as follows:

Swirl chamber (*W*):
Bore 3.75 in., stroke 4.72 in., watercooled.

Direct injection (*K*) (piston combustion chamber):
Bore 3.86 in., stroke 4.72 in., aircooled.

Balanced-pressure precombustion chamber (*GV*):
Bore 3.86 in., stroke 4.72 in., aircooled.

Figs. 1–3 show the construction of the combustion chambers in each case. The test was carried out on single-cylinder engines running up to 2200 rpm. Output and consumption data are shown in Figs. 4–6. Mechanical efficiency was the same for all three engines (72%). The result was that fuel consumption in the engine with the balanced-pressure precombustion chamber was not only the same but even slightly lower than that in the engine with direct injection. On the other hand, specific consumption in the engine with the swirl chamber is rather higher. In the engine with the balanced-pressure precombustion-chamber system operating at the above mechanical efficiency and at 2000 rpm the Saurer-Bosch apparatus measured approximately

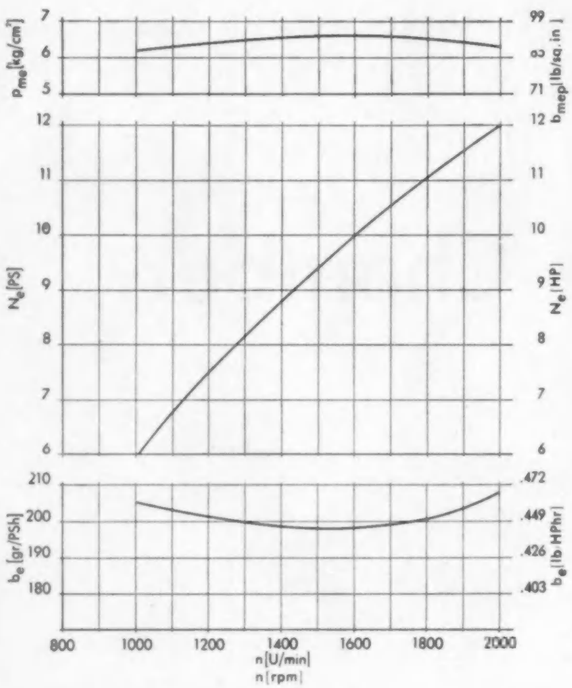


Fig. 4—Output and fuel consumption data for engine *W* (single-cylinder engine including accessories).

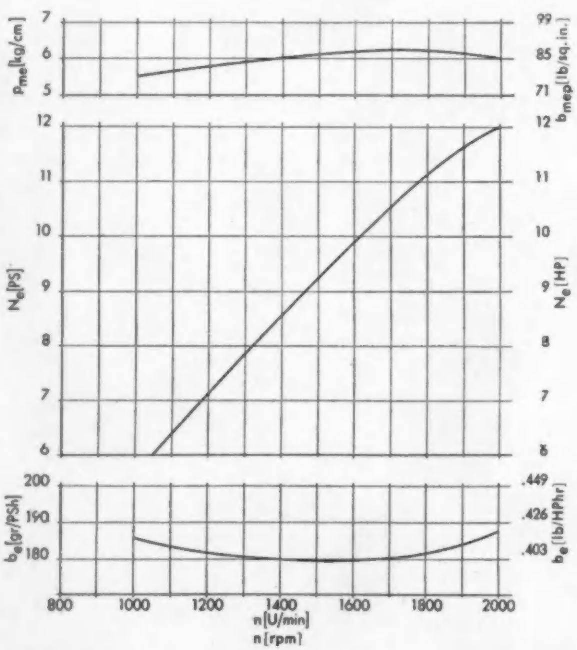


Fig. 5—Output and fuel consumption data for engine *K* (single-cylinder engine including cooling air blower and other accessories).

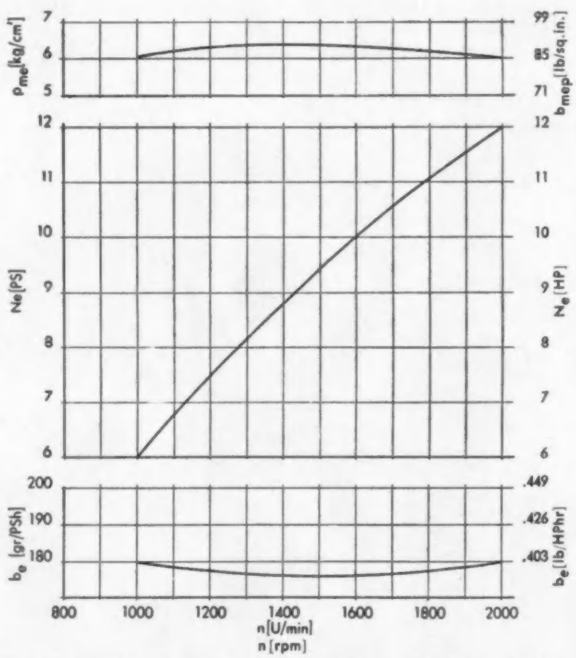


Fig. 6—Output and fuel consumption data for engine *GV* (single-cylinder engine including cooling air ventilator and other accessories).

32% discoloring of exhaust gas. The oscillograms shown in Fig. 7 were taken at 2000 rpm.

In each case the indicator diagram for diesel fuel and Mogas 80/86* is shown above, the speed of pressure rise ($dp/d\varphi$) shown in the center, and the body noise measured at the same time appears below. By observing equal technical conditions of measurement the inductive transmitter, which can be statically gaged, was installed in the main combustion chamber in such a manner that interfering influences were eliminated. The indicator diagram for the three systems shows appreciable differences when gas oil is used. The engine with direct injection has the highest firing pressure as shown clearly in the indicator diagram. Firing pressure in the swirl-chamber engine is somewhat less; the diagram of the balanced-pressure precombustion-chamber engine, however, is quite different from the others, and a rise of pressure caused by combustion is hardly visible. When Mogas 80/86 is used the performance figures differ even more noticeably. In all three cases the engine had the same injection setting for both Mogas and gas oil.

Engines with the direct-injection or swirl-chamber system show a rate of pressure rise and firing pressure intolerable in normal operation. Engines with the balanced-pressure precombustion-chamber system show scarcely any rise in firing pressure, nor does the rate of pressure rise show any appreciably higher values than those resulting from the combustion process. For the same injection setting as for diesel fuel the diagram shows simply a rather longer induction period. There is a close connection between combustion noise and rate of pressure rise. It is this sudden rise of pressure which causes the well-known and disagreeable diesel knock on air-cooled engines not fitted with a muffling water jacket. The influence of the system and of the fuel is seen in Fig. 7, showing body noise. Fig. 8 shows the relationship between combustion noise and the noise of the engine itself. In engines with direct injection, firing pressure rises from the relatively high figure of 1100 psi when diesel fuel is used to more than 1400 psi when Mogas is used. The rate of pressure rise increases from 120 psi to more than 280 psi per

* Mogas—motor gasoline—indicates fuel specified by U. S. Army under specification MIL-F-5572 A and MIL-F-25172 (7). Numbers 80/86 specify octane-number range.

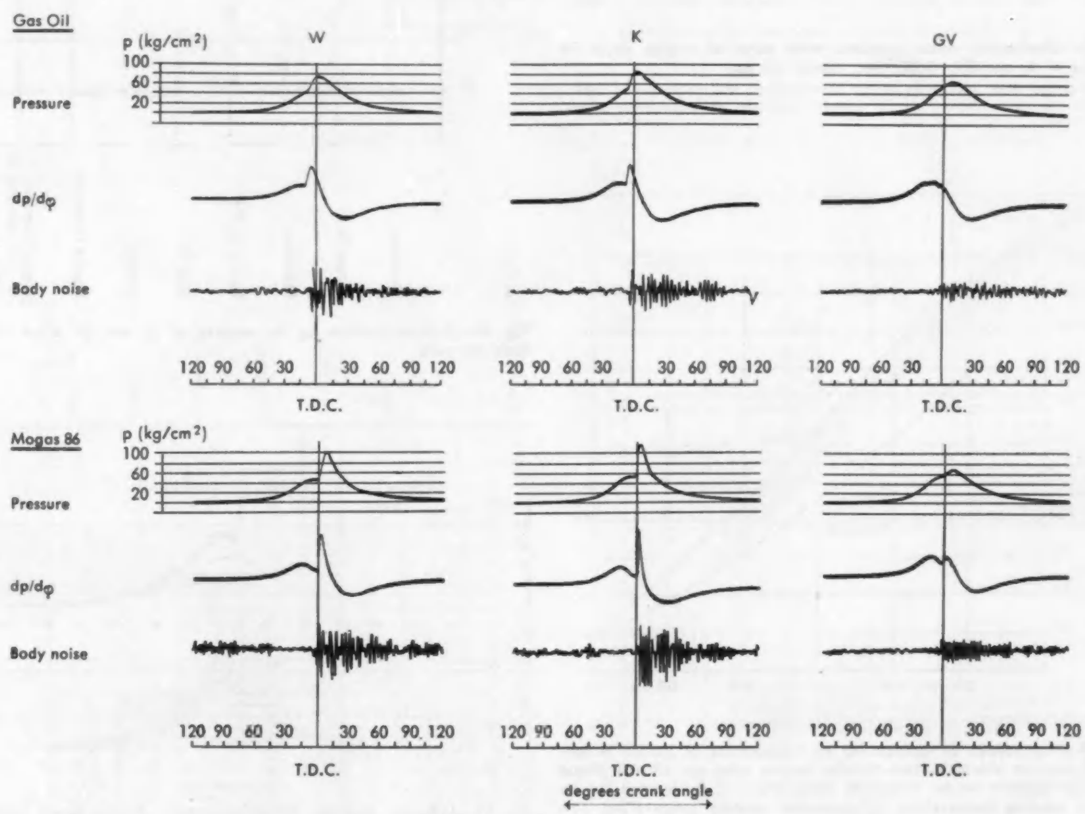


Fig. 7—Comparison of indicator diagrams, rate of pressure rise, and body noise for engines *W*, *K*, and *GV* when diesel fuel and Mogas 86 are used, 2000 rpm. Bmep = 85 psi.

degree crank angle, while ignition assumes explosive characteristics.

The swirl-chamber system performs more favorably, but its high firing pressure does not guarantee a safe and quiet engine operation. The performance of an engine with the new combustion system is quite different. Engines running on Mogas 86 or diesel fuel have the same firing pressure. The rate of pressure rise is also almost that of an engine with equal pressure combustion. The ignition lag is simply a little higher, which shows that another type of fuel has been used. The ignition lag—most important but not the only decisive factor—is greatly influenced by the combustion system, especially by pressures and temperatures, as shown by Fig. 9.

All the figures for ignition lag refer to the optimum value. The ignition lag periods were registered with the aid of a needle lift indicator and a vacuum photo cell or an ionization tract with a special oscillograph attachment. The ignition lag data for different fuels in all three engines are shown in Fig. 10, in each case in relation to data for the balanced-

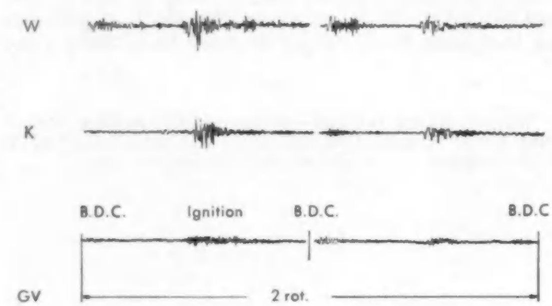


Fig. 8—Combustion noise compared with noise of engine itself for engines W, K, and GV. 2000 rpm. Bmep = 85 psi.

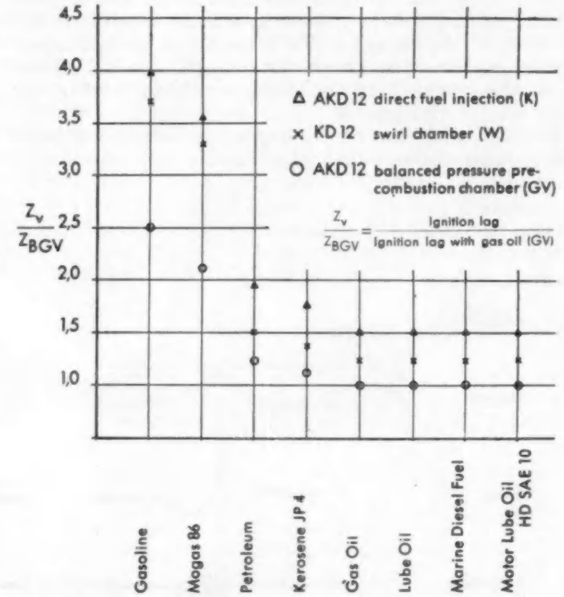


Fig. 10—Relative ignition lag for engines W, K, and GV when various fuels are used.

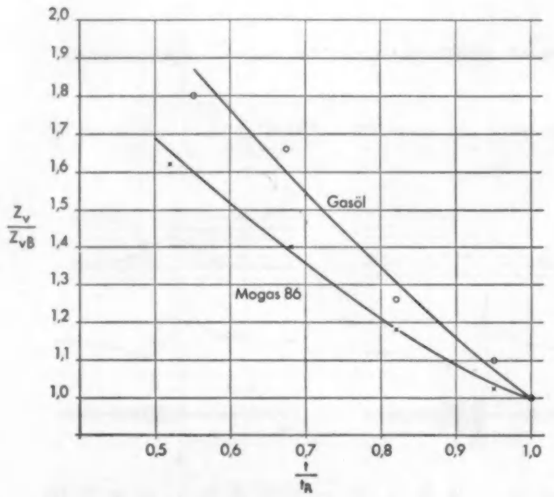


Fig. 9—Dependence of ignition lag on temperature of burner in balanced-pressure precombustion-chamber engine using gas oil and Mogas 86. Z_v = ignition lag for respective temperature, Z_{vB} = ignition lag for normal running temperature, t = respective running temperature, t_B = normal running temperature.

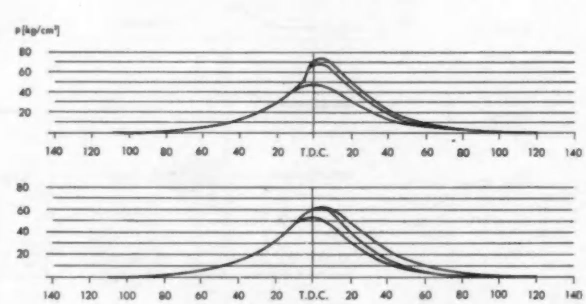


Fig. 11—Indicator diagrams for various loads. Above: direct injection. Below: MWM balanced-pressure precombustion chamber. 2000 rpm.

pressure precombustion chamber. A critical examination of the different systems cannot be undertaken on these figures alone, because only one part of the combustion process—indeed an important one—is influenced by ignition lag or induction period.

The balanced-pressure performance of the engine with the new combustion system is shown very clearly if, as in Fig. 11, the indicator diagrams for various loads are superimposed on one another. It is evident that an increase in output at a constant firing pressure results in an enlargement of the diagram size. On the other hand, diagrams of engines with direct injection show that the increase in the indicated medium pressure is related to an increase of firing pressure.

Can Use Variety of Fuels

The extremely favorable combustion properties of a balanced-pressure precombustion-chamber engine resulted in early experiments being made with vola-

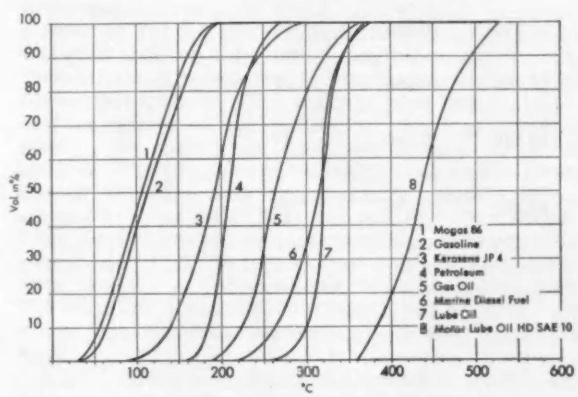


Fig. 12—Boiling points of various fuels used in tests.

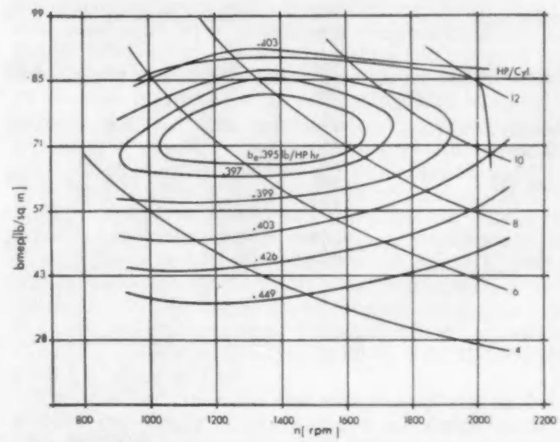


Fig. 14—Output and consumption curves of engine with balanced-pressure precombustion chamber (type AKD 312) when using gas oil.

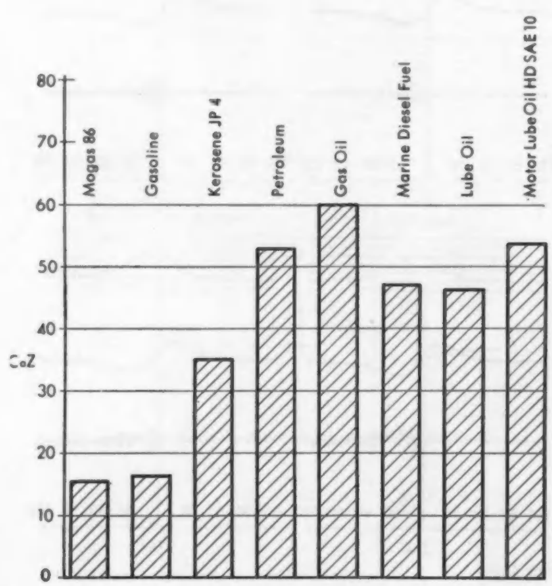


Fig. 13—Cetane numbers (CaZ) of fuels used in tests.

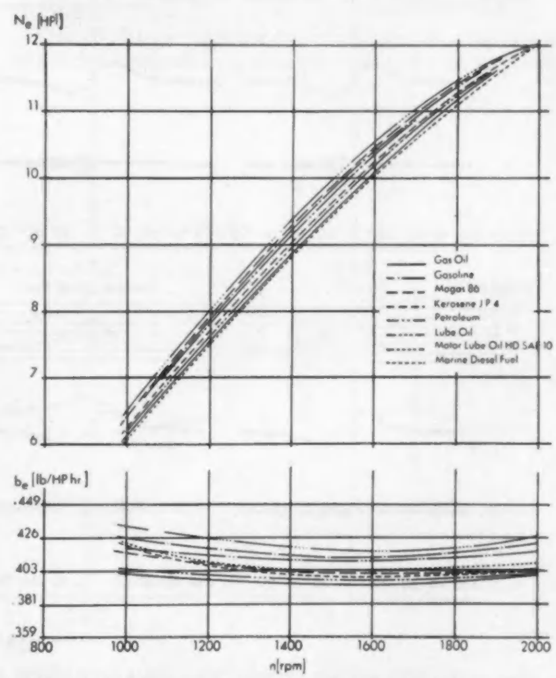


Fig. 15—Output and consumption curves of engine with balanced-pressure precombustion chamber when using various fuels.

Table 1—Essential Characteristics of Fuels Used in Tests

	Boiling Range, C	C, %	H, %	S, %	Specific Heat, kcal/kg	Specific Gravity	Cetane Number	Octane Number	Tetraethyl Lead, Volume %
Mogas 80/86	32–200	84.2	14.1	0.04	10,350	0.726	~15	86	0.08
Gasoline	30–180	86.0	14.0	0.06	10,500	0.720	~15	88	0.04
Kerosene JP 4	100–295	84.6	14.3	0.15	10,380	0.730	46		
Petroleum	160–270	85.8	14.2	0.19	10,290	0.790	53		
Diesel-Fuel	200–360	86.9	12.4	0.65	10,180	0.835	60		
Marine Diesel Fuel	220–365	85.5	12.4	1.52	10,100	0.880	47		
Lube Oil	260–370	86.2	12.6	1.40	10,140	0.890	47		
H-D Lube Oil—SAE 10	~360–520			1.00	10,200	0.876	53		

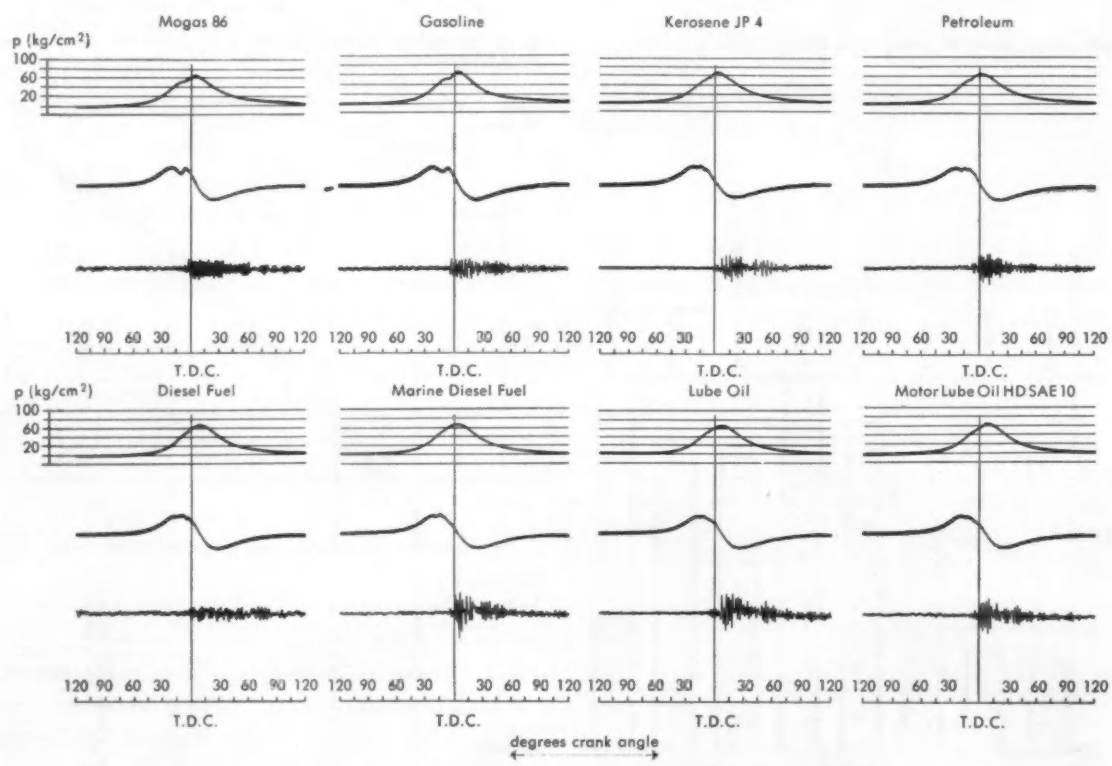


Fig. 16—Pressure rise, rate of pressure rise, and body no ise when using various fuels. 2000 rpm. Bmep = 85 psi.

tile fuels of crude oil distillation, such as petroleum and turbine fuel kerosene (JP 4). The injection timing remained unchanged, and it was found that the results of experiments made with these fuels scarcely differed from those made with gas oil—a result which could not be obtained with the other combustion systems. These favorable results led to experiments to ascertain the reaction of the engine to gasoline and the higher fraction up to vacuum distillation. Table 1 shows the essential characteristics of some of the examined fuels. The boiling point of the individual fuels is shown in Fig. 12. All crude oil distillates within this boiling range can be accepted as fuel. The cetane numbers lie between 15 and 16 (Fig. 13).

The results of the balanced-pressure precombustion-chamber engine using the various fuels described in Table 1 were all obtained without any addition of ignition aids, lubricating oil, or gas oil. The fuel-injection pump has a fuel leakage seal which prevents excessive fuel leakage and guarantees a certain degree of lubrication of the fuel-injection pump. No difficulties were encountered with the pumps. Fig. 14 shows the performance curves of the engine with the balanced-pressure precombustion-chamber (type AKD 312) for gas oil. Particularly striking is the very low variation in consumption between high and the lowest rpm and the very favorable reaction under part load. The greatest part of the diagram is given to the 0.40 lb per hp line. Exhaust smoke discoloring amounts to 30% under full load.

Fig. 15 shows output and consumption when using various fuels. The quantity injected was adjusted in relation to the specific gravity and the heat value or the special reaction of the corresponding fuel in such a way that the full-load output was the same in all cases. Hereby the exhaust gas discoloring, when using all fuels, was lower or at least similar to that when using diesel fuel. The engine runs thus on all fuels without any loss of output, and difference in fuel consumption only amounts to 0.02 lb per hp-hr. Obviously, it is also possible to mix fuels with one another to any required proportion. The conformity or dependence of consumption in the use of various fuels on their properties, such as heat value, specific gravity, composition, cetane numbers, is not ascertained.

The tolerance of the system for variation of fuel is clearly shown in the diagrams and in their differentiations, that is, in the rate of pressure rise (Fig. 16). Also here one observes a pressure rise for all kinds of fuel which is, for a high-speed diesel engine, unusually gradual. Rate of pressure rise and firing pressure are practically independent of the type of fuel used, and they require no alteration or adjustment. This can be observed with each type of fuel, whether under higher loads or with an idling engine, so that no misfires occur even after idle running of several hours. For comparison purposes, Fig. 17 represents two full-load diagrams at 2000 and 1200 rpm and a diagram representing long idling at 600 rpm for gas oil and Mogas 86. It can be said that an engine with the MWM balanced-pressure precombustion-chamber system operates efficiently regardless of the type of fuel (whether distillates, residual oil, or gasoline up to high octane numbers). The aircooled MWM 3-cyl diesel engine equipped with the balanced-pressure precombustion chamber, which is shown on the test bank in Fig. 18, operates with all types of fuel.

The gradual pressure rise completely avoids diesel knock—especially important for aircooled engines. Diesel knock is caused by air vibrations following a sudden rise in pressure, and in consequence this knock is radiated unmuffled as body noise in every direction and is particularly unpleasant when the engine is idling.

Fig. 19 shows a sound track of two idling aircooled engines installed in a tractor. One of the engines is

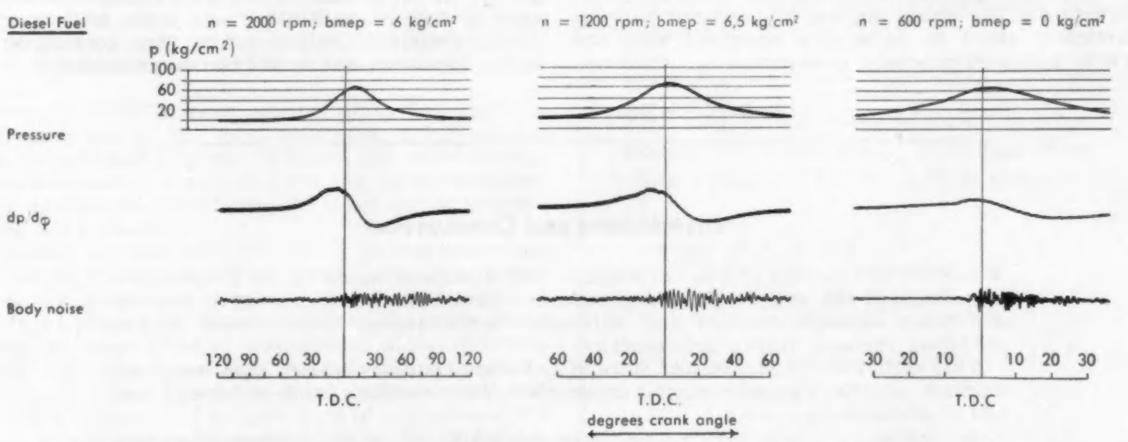


Fig. 17—Pressure rise, rate of pressure rise, and body noise in engine with balanced-pressure precombustion chamber under various loads.

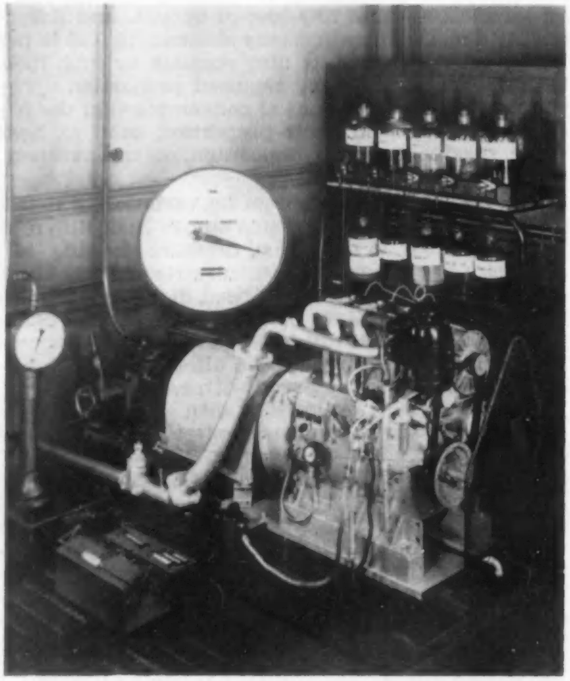


Fig. 18—Aircooled MWM 3-cyl diesel engine AKD 312D equipped with balanced-pressure precombustion chamber, running on test bank that has provision for use of different kinds of fuel.

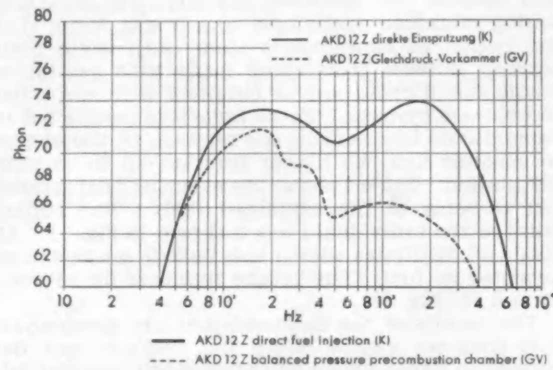


Fig. 19—Sound track of two idling aircooled diesel engines installed in tractor. One of engines is equipped with direct injection (*K*); other is equipped with MWM balanced-pressure precombustion chamber (*GV*).

equipped with direct injection and the other with the MWM balanced-pressure precombustion chamber. Here it was observed that the intensity of the unpleasant metallic noise of the higher frequencies is greatly reduced. The performance at higher rpm and load is even more favorable, as the volume of engine noise produced by gears, valves, piston, and blower equals or even exceeds combustion noise.

Starting at Low Temperatures

Cold-starting properties, which are extremely important for the diesel engine, are assured without particular effort in an engine equipped with the MWM balanced-pressure precombustion chamber. The combustion process in a cold engine naturally differs from that in an engine which has attained the necessary temperature. The excellent starting properties of an engine with high compression ratio using direct injection are achieved by injecting a rather larger initial quantity of fuel than usual through the burner insert. With the aid of the low heat capacity of the burner, which can be regarded as a kind of preparation, sufficient temperature for normal controlled combustion is reached after a very short time. Low-temperature starting on engines with a precombustion or swirl chamber is assisted by glow plugs or ignition paper.

Practical results indicate that cold starting at temperatures down to 14 F is possible after a few turns without any starting aid. With the aid of glow plugs or ignition paper, starting is possible at temperatures down to – 20 C, and single- and 2-cyl tractor engines can even be started by hand cranking.

(Paper, "System of MWM Balanced-Pressure Precombustion Chamber for High-Speed Diesel Engines," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Transmissions and Combustion

■ *Results of a survey of the Los Angeles traffic pattern, made by the Traffic Survey Panel of the Automobile Manufacturers Association, brought out a marked difference between manual and automatic transmissions with respect to the manifold vacuum during deceleration.*

This difference is significant since it is known that a relatively high manifold vacuum results in poorer engine combustion, thus emitting more unburned fuel to the atmosphere.

According to results which have been published, automatic transmission cars operating at a much lower percentage of time in this condition of high manifold vacuum should be a real benefit in decreasing the output of exhaust hydrocarbons.—From paper presented at SAE National West Coast Meeting.

New Equipment Automates Materials Handling

Based on secretary's report by **Daniel W. G. Roberts,** Aard Equipment Co.

A NUMBER of new devices provide automated handling of materials. Among these are:

1. Guid-O-Matic
2. Auto-select Conveyor
3. Plan-O-Bot

Among the techniques being applied to materials-handling equipment to make them automatic is a tractor-trailer system which will automatically travel throughout a plant without an operator. The new Guid-O-Matic system uses a guide wire which is mounted in the floor or above the tractor. Using this system, it is possible to automatically dispatch several tractors on the same system. Safety devices such as a bumper which cuts off the power have been installed on the tractors. Other safety devices are built into the system to avoid collision.

Another materials-handling device, the Auto-select Conveyor, automatically dispatches material from a traveling conveyor line onto a gravity line. The carriers roll by gravity into lift, or drop stations, where they are transferred down to the work area. One such system has selector bars which permit 225 different types of carriers to hang on the conveyor.

An operator at a drop station can select the coding he desires and dispatch a carrier to any other location in the plant. The system also permits automatic washing or degreasing of parts on the conveyor system. It is possible with this conveyor to receive material at one end of the plant, code it, and dispatch it to work stations throughout the plant.

The operator at each work station will perform his operation on the part, and after a full carrier has been finished he will dispatch that carrier back onto the conveyor recorded for the next operation. The carrier will automatically drop off at the desired work station.

Devices are also available which permit the adaptation of existing standard conveyors. These devices are systems which permit a signal to be stored with the piece as it is placed on the conveyor. The signal is transferred or transported along the conveyor with the piece to a predetermined location. At the location where the piece is to be used the signal is transmitted to some type of pusher and the piece is automatically removed from the conveyor.

A transfer device called Plan-O-Bot is used for such operations as removing parts from a die-casting machine, or feeding parts into punch presses. This device has a pattern of motions which can be easily changed as the operation changes. The travelling hand can swing horizontally 360 deg; it can raise or lower vertically 2 ft; it can extend inward or outward 2 ft; it can revolve about its arm 180 deg; and it has a motion similar to bending a man's wrist. The hand is detachable and can be replaced by various types of gripping devices depending upon the application.

In a typical operation in an automotive plant: the hand reaches 2 ft into the die-casting machine; grabs the sprue; pulls the casting from the die; and withdraws from the die-casting machine. It then turns horizontally to a quenching tank; dips the casting in water to cool it; revolves in a horizontal plane to a trim press; lowers the casting into the trim die; releases the casting; withdraws; activates the press; reaches back into the trim press; picks up the scrap sprue; revolves to a scrap bin; and releases the scrap.

In the punch press operation, the machine is set up to pass pieces from one punch press to another. The hand reaches in and grabs; withdraws; revolves; turns; positions the piece in the next press; withdraws; and activates the press. All that was necessary to change from the die-casting operation to the punch press operation was the insertion of a new cam pattern into the controls of the machine.

(This report together with other panel reports is available in full in multilith form as SP-318 from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $1.50; to members; $3.00 to nonmembers.)

THE PANEL which developed the information on Automating Materials Handling contained in this article consisted of:

panel leader: **R. L. Ballard,** Harrison Radiator Division, General Motors Corp.

panel secretary: **Daniel W. G. Roberts,** Aard Equipment Co.

panel members: **Robert DeLiban,** Barrett Electronics

Clifford P. Farr, Standard Modern Tool Co., Ltd.

Charles E. Kraus, K. D. I. Corp.

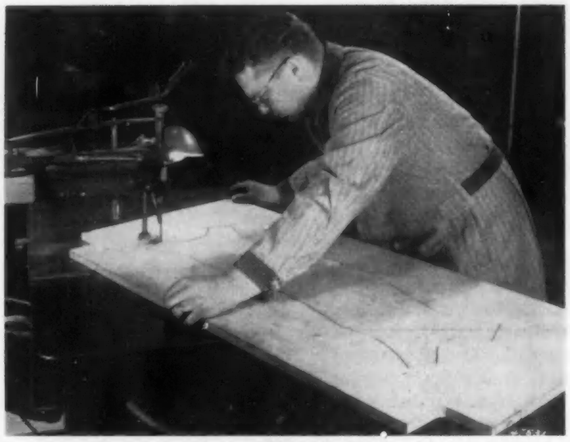
Robert E. Place, Planet Corp.

A New Low-Cost Blanking Tool

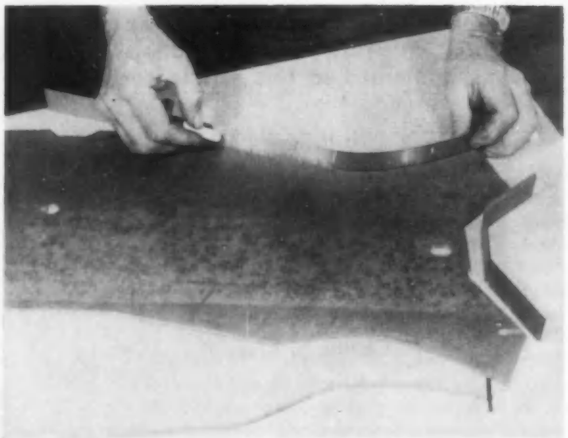
. . . bridges the gap till permanent tool fabrication is completed. Made of plywood, heat-treated steel rule, rubber, glue, and mild steel, this tool can be made with incredible speed. It will blank low-carbon steels up to ¼ in. in thickness and production runs as high as 250,000 pieces have been realized from a single die. Here is a description of the processing of such a tool.

Based on paper by **W. R. Wilson,** A. O. Smith Corp.

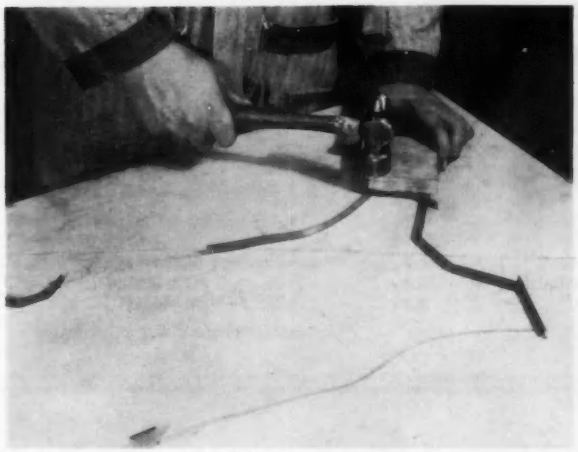
1. From a part print, a master blank (the contour of which is developed from a tryout of the form tools to be used in a production run), or a paper sketch, the contour of the part is scribed on a piece of plywood.



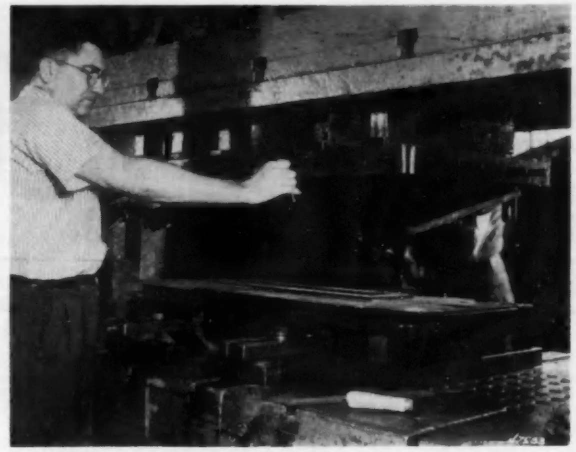
2. After the plywood is drilled through with access holes for the jig saw, the entire outline of the blank is sawed out. The width of the jig saw blade is dependent on the thickness of the rule, which, in turn, is determined by the stock thickness of the material to be blanked.



3. Steel rule of proper height and width is selected and cut and fit to the contour of the plywood board or master blank. Stock thickness and type of material being blanked are controlling factors in the selection of rule size. After forming to contour, the rule steel must be heat treated. Heat treatment consists of bringing the rule to 1450–1475 F and immediately quenching in oil at 100–120 F for two min. Tempering at 500–525 F for about 1 hr toughens the metal to a final hardness of approximately 55-57 Rockwell C, comparable to that of standard dies.



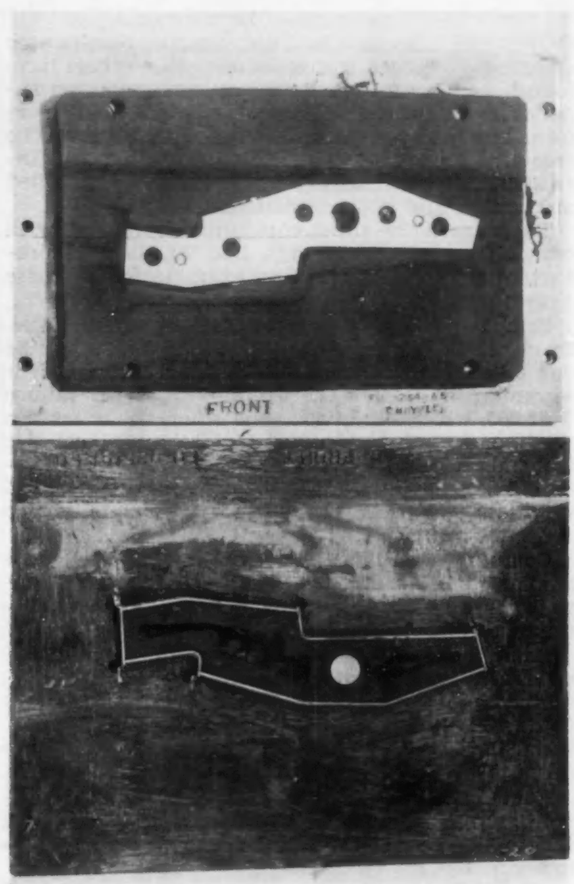
4. The rule die is assembled and rubber strippers glued in position for stripping material from the die. The completed die then proceeds to the surface grinder where the bevel or land angle is ground on the rule. Experimentation has proved that the land angle can influence the productivity realized from any individual die.



5. In processing the punch section of the tool, tool steel sections are mounted to ¼ in. mild steel backing plate or punch plate by the use of bolts and dowels. The punch, thus assembled, together with the completed die are mounted into a shoe in the press. The press is actuated and the outline of the die is transferred to the tool steel punch. Piercing punches, if required, are pointed to locate holes for drilling.

6. The tool steel is removed from the press and sawed to the defined contour, and any holes for piercing punches are drilled. Filing and fitting provide proper punch and die clearance. The tool steel punch is then hardened and ground. The hardening process is the same as for the steel rule. The punch is completed by adding rubber for stripping purposes.

(Paper, "Template Tooling," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



7. And here is a typical rule die and punch.

Table 1—Twin Hydra-matic Transmission Experience

Company Designation	A	C	E
Number Units, Total	84	91	10
Accumulated Mileage	12,450,000	20,950,000	1,113,951
Average Miles per Unit	150,000	238,068	111,395
First Failure	340 miles	230 miles	60 days
Average Miles before Failure	52,000	88,680	19,892
Months in Service	20+	20	22
Maintenance Cost, $	Not Available	Not Available	6,547.07
Maintenance Cost, $ per mile	Not Available	Not Available	0.0587
Average Fuel Consumption, mpg	1.34 mpg less than with conventional units	5.3	4.51

Automatic Transmissions

SOME operators have had discouraging results with automatic truck transmissions while others have found them entirely satisfactory, perhaps even superior to conventional transmissions. When performance has been disappointing, what has been the reason? Among the possible causes cited are: inadequate driver training, the shortage of qualified mechanics, and poor communications.

The experience three companies have had with twin Hydra-matics through Dec. 31, 1956, is presented in Table I. From an examination of these figures some clues to cause may be found.

Company A had its earliest failure at 340 miles. By no stretch of the imagination can this failure be due to anything other than poor material and/or workmanship. Here the average miles per failure is 52,000, which is not too good when the miles run per month is considered. Maintenance cost per transmission is not available, due to warranty failures, "fixes," and the like. Fuel mileage was 1.34 mpg less than with conventional transmissions in the same service.

Company C had its first failure at 230 miles and a similar conclusion can be drawn. At the same time, the average miles per failure jumps to 88,680. Maintenance costs are likewise not available.

Company E had fewer units, the accumulated miles and average miles per unit are less, but results follow the same pattern. The first failure came in 60 days. Based on average mileage, this means in about 10,000 miles. The average miles before failure dropped to 19,892, or about four months of service.

Fuel mileage for these units compared to conventional transmission vehicles, gives a spread of 1.05 to 2.32 mpg in favor of the conventional transmission.

Why the difference in operating results obtained by these three companies? A partial answer may be found in the experience of company C which had the greatest mileage between failures. When the first Hydra-matic was put into use, this outfit saw that driver education and training were essential and set up a program to do it. The twin Hydra-matic was something new and trained men were not available; they had to be developed. Company C is certain that the training paid off.

Experience of a Satisfied User

Fig. 1 depicts the life to date of 20 twin Hydra-matic transmissions in the service of a West Coast freight line, designated as company P.

Seven of these transmissions have never been out for overhaul. Mileages run from 255,000 for unit No. 1 to 60,000 for No. 7. This mileage averages 163,000 and represents an accumulated mileage of 1,152,000. All are still running.

Transmissions Nos. 8 through 11 have been out of the vehicle once and represent an accumulated mileage of 729,000 or a mileage per unit of 91,250. All are still running. Transmission Nos. 12 through 17 were removed twice. These six units have accumulated 935,000 miles, with an average life of 51,600 miles. All are still running.

Three transmissions were removed from service and returned to the manufacturer, but even with these included, the average life is 144,000 miles with 17 units still running.

Unlike companies A, C, and E, operator P finds fuel mileage no worse than with conventional units. After substituting motor oil of the type and viscosity specified by the manufacturer for type A fluid, they have transmissions which have run from 125,000 to 250,000 miles and are still in excellent working order. They look for a 300,000-mile original life before overhaul.

Seven mechanics were sent to the manufacturer's

Table 2—Four- and Eight-Speed Automatic Transmissions in Various Types of Service

	Soft Drinks	Truck Rental	Tractors, Miscellaneous Merchandise	Truck Rental	Beer Distribution
Type of Transmission	8 speed	8 speed	8 speed	4 speed	4 speed
Gvw, lb	16,000	16,000	42,000	14,000	14,000
Number of Vehicles	8	6	8	16	23
Average Age, months	24	16	10	12	24
Miles Run, 1956	81,705	100,399	211,786	320,283	130,938
Maintenance Cost, $ per mile[a]	0.031	0.0095	0.0195	0.0327	0.033
Gas Cost, $ per mile	0.049	0.029	0.047	0.0352	0.066
Average Miles/Month/Vehicle	420	1060	2640	1670	237

[a]Includes all maintenance.

. . . make some truck operators happy, others sad.

Based on paper by **Gorden H. Maxwell** Hertz Corp.

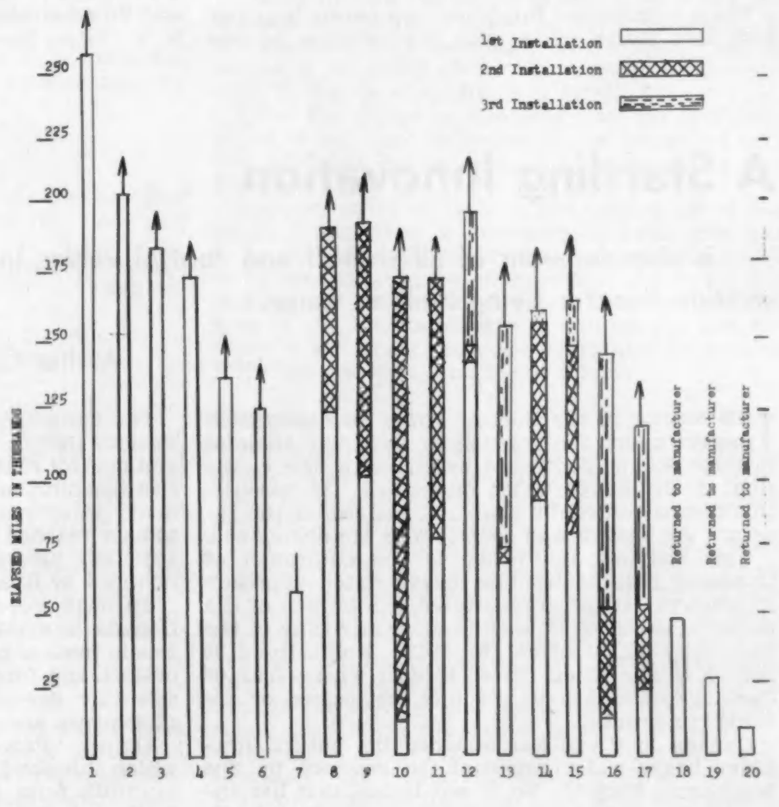


Fig. 1—Elapsed mileage for 20 twin Hydra-matic transmissions in the service of a West Coast freight line.

Hydra-matic training school. This training, along with additional advice and counsel from the manufacturer's field service representatives, solved the training problem.

Operator P makes two significant statements: they can make better time with a 200-hp diesel equipped with the twin Hydra-matic than with either a 225- or 250-hp diesel unit equipped with conventional transmission, and they feel they can take any given engine, regardless of make, attach a twin Hydra-matic, and increase engine life 33 1/3%.

Automatic Transmissions in Varied Service

Table 2 shows the results obtained with 4- and 8-speed automatic transmissions in various types of service.

During 1956, warranty was applied for on 106 transmissions. Of these, only four were repeat failures. In each instance new redesigned parts were furnished and in many cases, oil coolers had to be added, which were not provided originally.

When the first failures occurred with 4-speed transmissions in 1-ton units, high oil temperatures were suspected because of a burned condition of the clutch plates. On check, temperatures were found running to 200–212 F. The manufacturer agreed this was too high, so oil coolers were installed. This lengthened the periods between overhauls, but premature failures persisted. These were caused by failure of the vanes in the torus cover and breakage of springs in the torus cover hub.

The manufacturer furnished new covers together with new clutch plates plus the addition of one plate. All transmissions were then campaigned and there were only four repeat failures. There is evidence in these four cases that the proper new parts may not have been installed when the transmissions were last repaired. This is highly possible because the dealer, as usual, did not have the new "fix" parts in stock and the unit was needed for work.

While the automatic transmission has been a problem child, it can do a job. If the manufacturer will design a unit sound in engineering, use the best materials, test thoroughly with his facilities, give it to the customer on a test basis before merchandising, then the transmission will do the job.

The field and dealer organizations, and the customer's mechanical personnel must be thoroughly familiar with the unit before it is delivered. After delivery, the driver must be trained to handle the unit and instructed in the do's and don'ts of proper operation.

After lengthy experience, the owner must analyze costs against previous operation, from all angles, and decide on the economics of the installation. The automatic transmission is here to stay and we operators must recognize it. The manufacturer must do a better job of design, manufacture, and test. The operator must insist on training and assist in it. The driver must accept the units, be willing to be trained, and put the training into use. Then, and then only, will we reap the benefits of this transmission.

(Paper, "Operating Experience with Automatic Transmissions," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

A Startling Innovation . . .

. . . is abandonment of all shutoff and control valves in the Nuclear Power Demonstration Reactor being built in Canada.

Based on paper by **Arthur C. Johnson,** Nuclear Division, Canadair, Ltd

THE reactor in the Nuclear Power Demonstration project under construction by Canadian General Electric will be controlled by changing the elevation of the heavy water moderator. In essence, this means control by changing the size of the reactor. All shutoff and control rods are abandoned.

This startling innovation is one outgrowth of Canada's natural-uranium heavy-water approach to reactors. Its program started as a branch of the National Research Council in an empty wing of the University of Montreal in 1943. From there it moved to the Chalk River Project where four of Canada's experimental reactors are located or are being constructed.

Canada long ago was assigned the natural-uranium heavy-water approach to reactors by the Manhattan Project. So, it was logical that her approach to nuclear power should also be in this direction.

The Canadian GE Nuclear Power Demonstration Reactor (NPD), which is dispensing with all shutoff and control rods, is a 20 mw (electrical) reactor at Des Joachims near Chalk River. It will be the first heavy-water reactor for electrical power production to have reached the construction stage—unless construction progress has been made on those announced by Russia.

Through good fortune and good management, Canada is making an outstanding success of her role in nuclear power. In view of the rather limited outlook and funds that seem to exist in Canada for scientific development projects, Canada's accomplishments are even more remarkable.

(Paper, "Progress Report on Nuclear Power," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Constructing Defect-Free Plastic Tooling

Based on paper by **Edward R. Kalis,** General Motors Corp.

SOME of the problems which have been encountered with tools made of epoxy resin are: 1. shrinkage; 2. warpage; 3. wavy surfaces; 4. twist; 5. chipping.

Here are some tips on how to avoid these problems in body die and tool construction.

Shrinkage

Dimensional shrinkage is caused by oversaturating the fiberglas cloth. As a result, the laminate will overheat (due to exothermic heat reaction) and upon curing and cooling will shrink.

The proper way to saturate the fiberglas cloth is on a table that has been waxed with paste wax or one that is protected with wax paper. The next step is to tailor the fiberglas cloth and place it on the table. Then pour a sufficient amount of resin on the cloth and spread over the entire surface. When the fiberglas cloth is thoroughly saturated, remove all excess resin from the glass cloth by scraping it to one side of the table. (This resin is to be used for the next laminate.)

If these instructions are adhered to, a resin-rich laminate and overheating are eliminated and dimensional stability results.

Warpage

When there is excessive resin in the fiberglas laminate, the resin will drain into the voids and pockets causing hot spots that create uneven curing and cause warpage in the spotting aid. Therefore, wood models with large contours and deep depressions are usually difficult to build spotting aids to. Proper care should be taken to insure an even distribution of resin in the fiberglas laminate.

Warpage also results if exceptionally large fillets are not avoided whenever tempered-masonite backing or fiberglas-tubing framework is attached to the back of a fiberglas laminate. The mass of fillet will overheat on curing and will build up stresses and strains in the fiberglas skin which when released from the wood model will warp out of shape.

The frame or backing should be fitted to within ¼ in. of the surface of the laminated fiberglas skin. (Masonite or plastic tubing may be used.) Also, the fillet should be restricted to a size of ½ in.×½ in. ×45 deg .

Wavy Surfaces

Wavy surfaces are caused by the excessive heat generated when too much epoxy resin is used in attaching the frame to the fiberglas laminated skin. When excessive fillets are used in this region, wavy surfaces will also result because the mass of resin will overheat and will soften the laminated skin upon curing. The fillets will shrink and pull the skin, causing the hollow spots in the face of the fiberglas laminated skin.

When aluminum castings are placed on the back of laminated skins for checking fixtures, some castings do not fit the contour of the skin. In such instances a scrap piece of aluminum or masonite, the same thickness as the ribs on the casting, may be placed in the larger gaps and welded in place with a paste made up of resin mixed with fiberglas fibers or cotton floc. In all cases, be sure to avoid any fillet over ½ in.×½ in.×45 deg. If these instructions are closely followed, wavy surfaces will be eliminated.

Twist

Twist may result when a frame is constructed under stress and strain—for instance, where clamps hold the pieces together while applying fillets. Egg-crate constructed tempered-masonite frames are recommended here because the frame is held in place by its own construction and when fillets are applied, the frame is under no stress or strain. It is important that the frame be completely set up before it is attached to the laminated fiberglas skin, in this way avoiding any twist.

After the frame is completely set up and resin cured, it can then be tacked to the laminated skin and provision can be made to fillet the entire surface.

Another cause of twist is the cutting off of too much frame when a laminated fiberglas area has to be changed. To avoid this, reinforce the frame in an area close to the changed area before cutting out the old part of the frame. Then cut out the area of the laminated skin to be changed and replace it with new glass and resin and proceed to fillet the new skin area to the frame.

Chipping

It is a common occurrence for die aids or spotting blocks constructed of reinforced fiberglas and epoxy resin to be chipped by bumping against castings, benches, or such in the shop.

The writer urges everyone to be careful when brushing the face or surface coat of epoxy resin on the wood or plaster model. Keep the coat as thin as possible and keep it from building up in small depressions, crevices, and low edges. Be sure to get the fiberglas as close to the surface as possible. Small pieces of fiberglas or glass rovings may be used in the crevices and crease lines. Avoid resin-rich spots and the results will be much better.

(Paper, "Tips on Aids for Body Die and Tool Construction," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Slow Run-In Traced

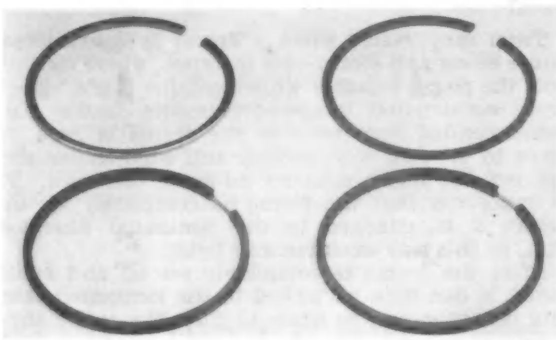


Fig. 1—This ring combination employs an unpopular type of oil ring but it does a good job of oil control. The low-stress, low-rate coil spring applies a gentle push at approximately 100 points in accurately controlled amounts.

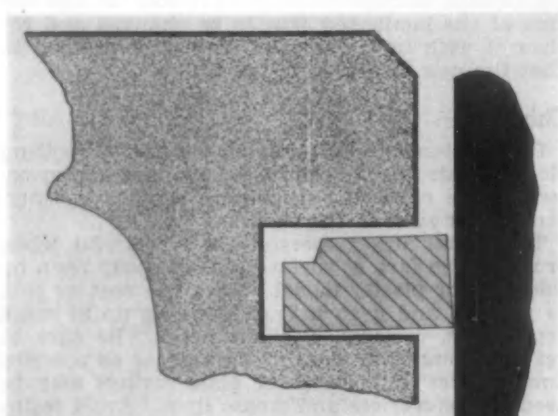


Fig. 2—This torsional-type compression ring is now in almost universal use, sometimes in conjunction with face taper.

THE variation in oil consumption occurring during run-in of various engines is due to mechanical factors rather than to the oil or its additives. This is the conclusion drawn from a test run-in program which covered piston rings, ring assembly, and critical engine components.

In the first phase of the investigation, the oil ring used in the ring combination was of the chrome-plated steel rail, spacer, and flat expander spring type. At that time (1954) all ring producers assumed the initial face accuracy of steel rails to be unimportant since the expander was expected to give them complete cylinder contact. This assumption was probably valid for unplated rails, as originally used, but was invalidated the moment chrome-plated rails appeared on original equipment. Observation of several thousand new engines per day proved rails must have almost perfect cylinder contact without benefit of expander to give consistently smoke-free engines.

Had the tests begun with steel rails lapped to near perfect accuracy as we now make them, the second phase of testing might have been unnecessary. Yet the basic design lacks other important characteristics for this kind of laboratory comparison. A high degree of conformability is necessary, particularly for tests in worn cylinders. Expanders help in this respect, but the modulus of steel is 30×10^6 as against 14.5×10^6 for cast iron. Moreover, any flat expander is inherently a high-rate, high-stress creation which has a load variation of approximately $\pm 25\%$ of the mean, which is applied with something less than perfect uniformity. And in addition, the round faces of the rails change area and unit pressure rapidly with wear.

In the second phase of the investigation, accurate comparisons and good repeatability were obtained with the ring combination shown in Fig. 1. Only the oil ring was changed, and the switch was to a type never popular but which has some important concealed assets. Being made of cast iron with a modulus of 14.5×10^6, it requires only about half as much push from the expander to conform to a given

Based on paper by **Arthur M. Brenneke,** Perfect Circle Corp.

to Mechanical Factors

cylinder irregularity. And the low-stress, low-rate coil spring applies that push at approximately 100 points in accurately controlled amounts. Note also that the lapped flat scraping faces not only are accurate in their cylinder contact, but inherently provide accurate area control which is unaffected by wear.

Effect of Compression Rings

Compression rings can be equally important in their effect on initial oil consumption and it is the top ring that's most important. Its initial cylinder contact must be such as not to have an upward scraping action. Such a condition cannot be corrected or compensated for by any amount of work on the oil ring. Engine and ring people learned in the 1920's that simple rectangular top compression rings invariably developed initially this kind of top corner cylinder contact because most of the pressure and thermal and mechanical forces affecting pistons and rings worked in this direction. The use of approximately a 1-deg taper across the ring face was conceived as a solution and its use started then. In the early 1930's, torsionally twisted designs, such as shown in Fig. 2, were conceived for a similar purpose and were found to have better sealing ability. They are used almost universally today, sometimes in conjunction with face taper.

When chrome-plated rings with lapped faces arrived, our knowledge of the effect of top ring to cylinder attitude was further expanded. We discovered corners didn't have to be square and sharp as we had assumed. It is only necessary to avoid a smooth blend of corner radius into the face as shown in Fig. 3. It was also found that top corner contact did not occur even with plain rectangular rings because ring faces lapped with loose abrasive are not flat, but convex to the extent of approximately 0.0001 in. in ⅛ in. In contradiction to old axioms and assumptions, this sort of cylinder contact was found to provide good gas seal and good oil economy as long as top corner scraping is avoided. However, this cannot be taken advantage of often, because the inherent convexity usually is not sufficient to compensate for piston and cylinder conditions. What has been said of top compression rings applies equally to intermediate compression rings, although the latter are much less sensitive and less important in their effect on performance.

Piston-Ring Assembly

The piston-ring assembly must be given careful attention if run-in difficulties are to be avoided. This is particularly true of compression rings, which must be designed to have an assembly stress value

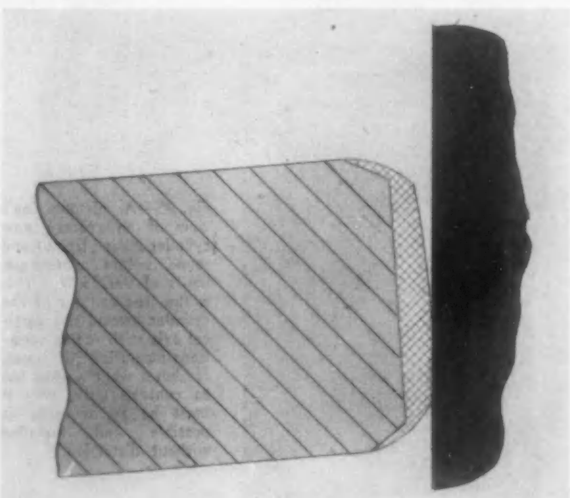


Fig. 3—In the compression ring face to corner relation the corners don't have to be square and sharp but the smooth blend of corner radius into the face, as shown here, should be avoided.

near the yield point of the material. Only the best tools should be used and the best are none too good. The tool shown in Fig. 4 incorporates the two most important features for safe assembly. The ring is opened into a supporting form, which prevents stress concentrations and has stops to prevent excessive opening. This tool is not popular and it has not sold well in the 20 years it has been available. A separate tool is required for each 1/16-in. diameter step and the tools are more expensive than some of the more popular gadgets designed to reduce operator effort rather than to provide safe ring assembly.

Fig. 4—This is the best tool for piston-ring assembly. The ring is opened into a supporting form which prevents stress concentrations, while stops prevent excessive opening.

Engine Factors in Slow Run-In

Engines present far more run-in pitfalls for the unwary than do piston rings and conditions prevailing in cylinders are the most important of all factors. Fig. 5 portrays a model of an average new cylinder which is straight and round within commercial limits of 0.0015 in. This is the true contour of the cylinder around the vertical axis with radius variation magnified 300 times. It is the way a piston ring sees a cylinder and it isn't surprising that some of these abrupt changes in radius are often frustrating to even the most willing and accommodating ring. The prospect of trying to conform to all these varying contours while sliding up and down over them at 30–40 mph must be staggering. Since the ring's variation from true roundness may either compound or cancel cylinder variation, it is easy to see why a ring must be as accurate as possible and why avoidance of distortion in assembly is so important.

The model is shown here without the head in place. Head attachment and/or thermal stress magnify the variations although the basic contours prevail. The extent of the added distortion depends largely on the head gasket and torque applied to the hold-down means, hence it is most important that head and top deck surfaces be flat, that the head gasket used be designed for the engine and installed with holddown torque specified by the engine manufacturer.

Cylinder geometry in terms of radius variation makes it obvious that the contribution of wear to the run-in process must be what it does to cylinders. The need for fur or nap of some kind to let the hills be leveled off quickly, and surface interruptions to prevent damage from scuffing in the process, is apparent. A honed finish of 20–30 microin. rms is accepted universally for new cylinders. When installing new rings in used cylinders, the surface left by the original rings is best unless scuffed or scored.

Fig. 5—A piston ring's view of an average new cylinder made straight and round within commercial limits of 0.0015 in. This is the true contour of the cylinder around the vertical axis with radius variations magnified 300 times. It shows what a ring has to contend with, why it must be as accurate as possible and installed without distortion.

Effect of Cylinder Coatings

Cylinder surface treatments are sometimes a factor in so-called slow run-in. Two such coatings in use are Lubrite and Surfide. Their purpose is to prevent scuffing and usually they tend to retard run-in. Both are etching processes which produce an interrupted surface and leave a strong coating of iron sulfide or phosphide. Chemical or metallurgical variations sometimes result in excessive porosity, which causes high oil consumption until the voids fill with deposits or until wear reduces the area. Void area in excess of 30% makes oil control virtually impossible.

Cylinder liners, wet or dry, must be given close attention if quick run-in is expected. Top end supporting shoulders and their relation to counterbore in the top deck and the head gaskets are extremely critical. Fig. 6 incorporates all the things that should NOT be done. The shoulder must seat squarely and flatly in the counterbore and the gasket head must not overhang the shoulder. The conditions shown in Fig. 6 are one of the most common causes of upward scraping top rings and slow run-in. The O-ring end of the wet liner is less critical than

the top end, but O-rings and grooves must fit properly or the liner will be distorted. Dry liners are touchiest of all as regards run-in. Inaccuracies of block bore, sleeve OD and ID combine to produce a wrinkly type of distortion which severely taxes the conformability of piston rings. The subject is too complex and controversial to say more here than to treat dry liner engines with utmost care.

Pistons Affect Run-In

Pistons play an important part in run-in. Ring grooves, particularly the top one, must be square and flat. Out-of-squareness is a frequent cause of top corner contact of top rings, and in fact accounts for practically all of it not the result of improper liner conditions. Manufacturing processes make unsquare ring sides highly improbable. In the case of used pistons, interference of the new ring with a wear step in the groove or grooves that are worn in a bell-mouthed fashion, should be avoided. Piston skirts should have the proper cam, but skirt taper is even more important in the control of oil. A piston which fits the cylinder as shown in Fig. 7 presents an impossible run-in problem. Proper wrist-pin fit is important. Tight pins should be avoided because they prevent the expansion control feature from functioning, resulting in reverse skirt taper or seizure.

Valves are Big Oil Consumers

Valves have always been an overlooked source of oil consumption, but since all of our engines are now of the overhead valve variety, they certainly can't be safely ignored. Of the total oil consumed in current production passenger cars, as much as 75% disappears via valve stems and guides. Surprisingly enough exhaust valves are often almost as great contributors as intakes. The problem of supplying enough oil to the right places to keep the mechanism in the rocker boxes from squeaking at idle speed and not oversupplying at high speed is a tough one. The effect of stem-to-guide clearance on oil passage is a relationship that also exists for every metering bearing clearance in rocker arms and rocker shafts. Here is a source of slow run-in that needs more attention! It will become an increasingly important source of error in development and evaluation of fuels and lubricants.

Don't Blame Additive Oils

The only yardstick for run-in that we use is oil consumption and, specifically, how long the engine must be operated before the oil consumption rate stabilizes or reaches a satisfactorily economical figure. But the trouble is that while everyone thinks in terms of oil consumption, they talk in terms of wear, and there is really no proved correlation between wear and run-in.

In all dynamometer and road testing we have used premium oils, also indiscriminately in new engines, completely rebuilt engines, and in re-ring installations in very badly worn equipment. While we occasionally encounter slow run-in problems, we have been unable to blame it on the lubricating oils. We find usually that we have bungled some mechanical detail.

We are not prepared to state flatly that a run-in problem does not exist with high additive oil, but we state without qualification that we have no first-hand experience indicating its existence. We have never seen any good, solid, clear-cut, factual data from any source proving that such a problem exists.

Paper, "The Heavy-Duty Oil—Slow Run-in Question," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 435 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

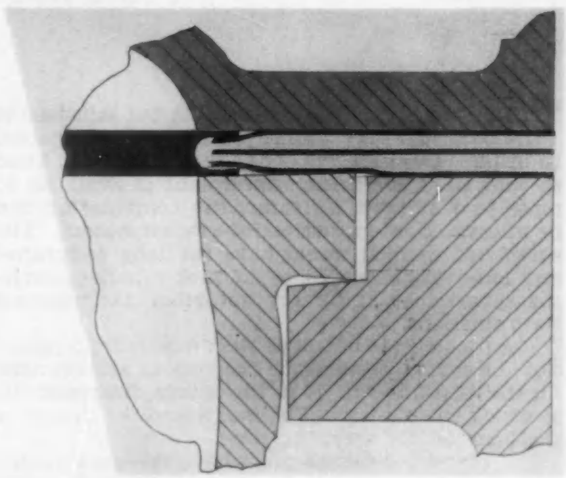


Fig. 6—A composite of all the things that shouldn't happen to a cylinder liner. The shoulder must seat squarely and flatly in the counterbore. The gasket must not overhang the shoulder. Conditions shown here are most frequent cause of upward scraping top rings and slow run-in.

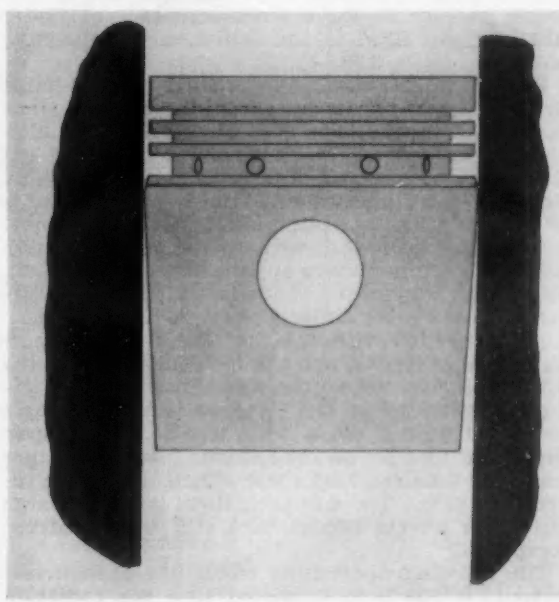


Fig. 7—A piston fitting a cylinder in this manner presents an impossible run-in problem.

Men, Materials, and Maintenance for the

THE United States Navy is working out solutions to the problems that nuclear seaplanes are expected to bring. The aim is to have information at hand so that when a nuclear powerplant is available to mate to a suitable airframe, the combination can be integrated into a successful weapon system. The completed weapon would have the long endurance and long range needed to counter missile-launching submarines and carry out other far-reaching Navy missions.

The problems to be solved stem mostly from radiation, of course. Radiation has serious implications for the men who will fly in the planes, the materials of which the planes will be made, and the design of the facilities for servicing them.

The aircraft designer must have the crew radiation tolerance established prior to design. Its value has a profound effect on shield weight. This introduces the question: what is the allowable reactor radiation dose that can be given to the flight crew?

Examination of the problem indicates that nuclear radiation causes immediate effects, within 30 days, and latent or long time effects. Immediate effects, such as nausea, vomiting, and loss of hair result from fairly large doses—upwards of 75–100 REM (where REM is the radiation dose unit of measure).

For the military seaplane problem, it was found that five major effects exist from the medical viewpoint: (a) degradation of performance, (b) incidence of cataracts, (c) incidence of leukemia, (d) shortening of life span, and (e) genetic mutations. These are the things we would like to avoid. Studies to date have indicated that our dose program could be increased somewhat without risking any degradation of performance or any incidence of cataracts. This is also true for the incidence of leukemia; however, this is a more difficult effect to evaluate.

In connection with the first three effects—performance, cataracts, and the incidence of leukemia—there appears to be a threshold dose. By restricting radiation below this level we can avoid these effects altogether. This is not true of the life-span shortening and the genetics effects. No matter how small the dose received, these effects cannot be reduced to zero. The question, then, is: "How large can these effects become and still be considered acceptable?"

The life-span-shortening effect has been investigated; it has been predicted that the radiation shortening of life span will be less than other occupational hazards. Military pilots have a predicted life span of from 8 to 12 years less than the average population. Heavy coffee drinking and smoking may cause shorten life span 5 to 10 years. Fifty pounds of excess fat can shorten life span by two years. In connection with the genetic effects problem, indications reveal that radiation produced genetic mutations can be made negligible in comparison to the present national average of about one in 25.

Examination of biological radiation history shows that since the first severe case of x-ray dermatitis in 1896, the tolerance trend has been toward greater and greater restriction of maximum permissible radiation exposure. The National Academy of Sciences and the National Bureau of Standards have both recommended radiation limits. The former suggests a total accumulated dose not to exceed 50 REM at age 30 and 100 REM at age 40. The Bureau of Standards recommended limit very nearly approximates these values.

Although a Naval aviator's career as a pilot may last 18 to 20 years, only 5 or 6 years of this time would probably be used for operating nuclear-powered aircraft. His normal flight training, squadron duty, post graduate school, and usual tours of shore duty would take the remainder of the time. This means that dose rates used in the design of aircraft can be increased significantly with resulting reduction in shield weights. Such career programming can provide a total accumulated dose to the pilot of 90 REM at age 40. This leaves a margin of 10 REM for background radiation and medical x-rays.

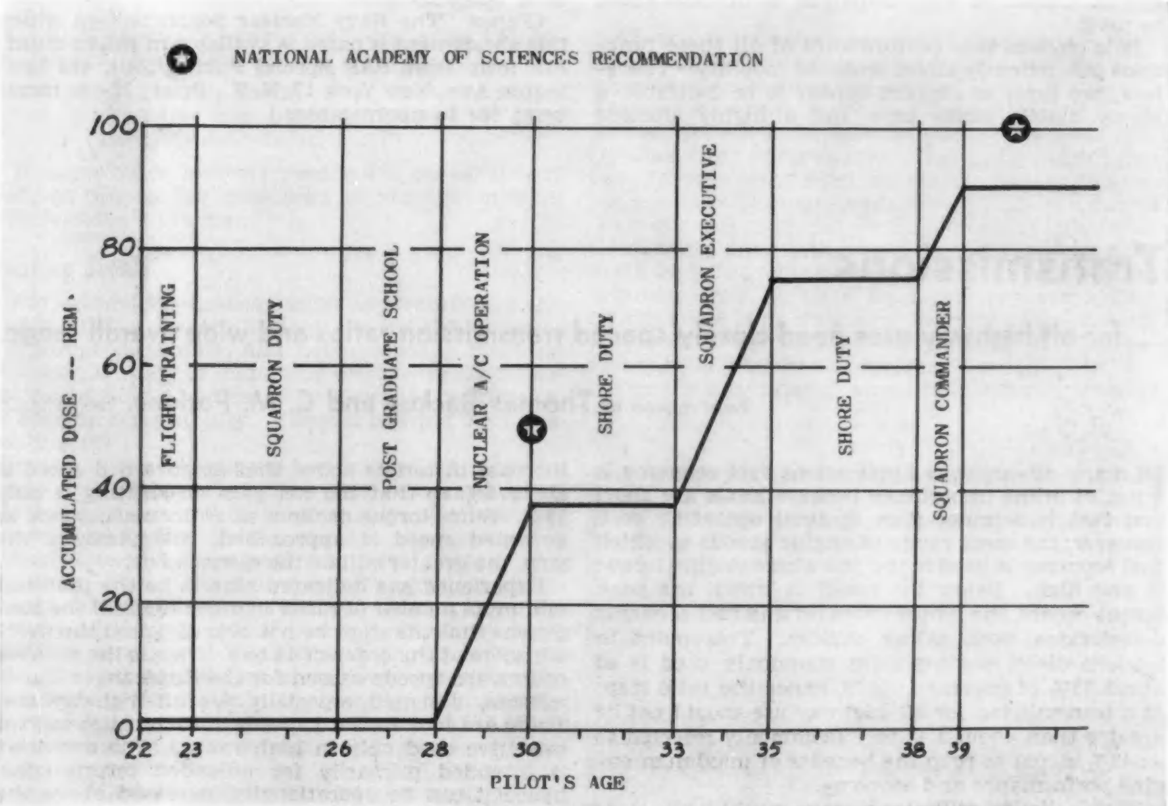
Within the framework of biological requirements, the major problem with shielding is the attainment of minimum weight for a fixed radiation dose rate. Major shield weight savings may be realized by using a divided shield where the biological protection is arranged around both the reactor and the crew.

But, the division of shielding between the reactor and the crew compartment affects structural weight, performance, and aircraft stability. The greater the weight of the shielding in the crew compartment, the greater will be the structural weight required to carry this load. This is especially critical for a hull-type seaplane since the bow landing load factors due to vertical and pitching accelerations are as high as 12 to 16 *g* in the vicinity of the crew compartment; this compares to approximately 6 *g* for a ski-equipped airplane.

Radiation from the reactor complicates the servicing and handling problems. Powerplant removal involves lifting a very large mass. Substantial over-

Nuclear—Powered Seaplane

Excerpts from paper by **Commdr. A. D. Struble, Jr.,** Bureau of Aeronautics, United States Navy



NAVAL AVIATOR'S CAREER could be planned so that only five or six years of his 18-20 years as a pilot would be used for operating nuclear-powered aircraft. National Academy of Sciences recommends total accumulated dose be held to 50 REM (units of radiation dosage) by age 30 and to 100 REM by age 40. At a rate of about 19 REM per year, a man could serve his first two years in nuclear operation in his late twenties, two years as executive of a nuclear squadron in his mid-thirties, and a year as commander of a nuclear squadron in his late thirties—and still have a margin of 10 REM for background radiation, medical x-rays, and other chance exposures.

head structure is required to lift the powerplant, and provisions must be made for guiding the reactor out of the aircraft to prevent swaying. Swaying might cause serious damage to the aircraft structure.

Fuel life has definite limits, and reactor time is accumulated quickly in the long-range Navy missions. Therefore, facilities must be provided for renewing spent fuel. Replacing the complete power package or returning the aircraft to its home base are two possible answers.

For some extreme designs aircraft returning from a mission will be radioactively hot. Before service or maintenance can be conducted, additional shielding must be placed around the reactor. This shield can be in the form of a liquid which is pumped aboard through lines that are remotely connected to the aircraft. Use of sea water in this capacity has been studied.

The decaying fission products continue to produce quantities of heat for several days after the reactor is shut down. This heat must be removed or the reactor will melt. An auxiliary power unit is provided in the aircraft for this purpose.

Remote checkout of powerplant systems may be required to minimize the maintenance crews' exposure to the residual radiation in the aircraft. A system similar to that employed in missiles could be used.

It is obvious that performance of all these functions will seriously affect seabased mobility. Therefore, two types of support appear to be desirable, a highly mobile strike base and a highly efficient maintenance base. Logistic submarines have been suggested for the mobile strike bases. Various barge and ship tenders have been proposed to handle the maintenance sea base.

Home base of the nuclear seaplane will require special installations. A "hot" engine test stand must be provided which is capable of operating the entire nuclear powerplant at full power on the ground. This test stand will be functionally the same as any other test stand, but physically it will be completely different due to the radiation and hazards associated with the nuclear powerplant. A mating station will be required to accomplish the remote mating and demating of the nuclear powerplant from the airframe. Due to the high residual nuclear radiation associated with the powerplant, the "hot" engine shop will have to be properly equipped to perform all maintenance and overhaul procedures with all the operating personnel protected by suitable biological shields.

A complete layout must provide for bringing a nuclear-powered seaplane onto the beach, augmenting the shield, mating it for removal of the powerplant, and performing hot-cell maintenance of the powerplant. The site must also contain isolated nuclear engine run-up stands, remating and flight preparation areas, and a "cold" area for non-nuclear operations.

(Paper, "The Navy Nuclear Seaplane," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Transmissions . . .

. . . for off-highway uses need closely spaced transmission ratios and wide overall range.

Based on paper by **Thomas Backus and C. M. Perkins,** Fuller Mfg. Co.

IN many off-highway applications fuel economy is not of prime importance because hauls are short and fuel is a minor item in total operating cost. However, the same range of engine speeds at which fuel economy is good is the one where engine torque is also high. Below the speed at which the peak torque occurs, the torque drops off and fuel economy deteriorates, both rather rapidly. This point in modern diesel engines most commonly used is at about 70% of governed speed, hence the ratio steps in a transmission for off-highway use should not be greater than about 1.42 to 1 (commonly referred to as 42% steps) to reap the benefits of maximum engine performance and economy.

Within limits, still closer steps would have some advantage, but due to the drop in torque from the 70% point to governed speed, the gain in torque on a ratio change is less than the change in ratio. For example, with a ratio step of 20% and an engine governed at 2100 rpm, the down shift would be made at 1750 rpm. At this speed in a typical engine the increase in torque above that at governed speed is about 5% so that the net gain on shifting is only 15%. Since torque declines at an increasing rate as governed speed is approached, the narrower the step, the greater will be the discrepancy.

Experience has indicated nine to be the practical minimum number of ratios in order to fulfill the conditions that the steps be not over 42% and the overall range of the order of 14 to 1. This is the number of forward speeds chosen for the Roadranger transmission, designed especially for off-highway use. There are four forward speeds in each range and an overdrive used only in high range. The overdrive is intended primarily for unloaded return trips, hence it can be operationally increased above the approximate 40% which obtains on all other steps in order to extend the overall speed range.

(Paper, "Efficiency and Simplicity in Off-Highway Transmissions," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Vacuum Melting of Steels Improves Engineering Properties

but cleanliness and cost remain as problems

Based on secretary's report by **H. C. Rezeau, Jr.,** General Motors Corp.

VACUUM melting improves the engineering properties and formability of:

1. Bearing steels.
2. Valve and stainless steels.
3. Low-alloy steels.

In many cases, however, results are not consistent and, of course, the economics of vacuum melting still remains a problem.

Bearing Steels

For critical applications such as aircraft engines and aircraft accessory devices, the individual bearing life predictability, and not how many bearings will exceed 10% of handbook or the average life ratings of a large number of bearings, is the criterion of bearing acceptability. Vacuum melting increases bearing life.

Fig. 1 shows laboratory test results of bearings made from both air-melted and vacuum-melted 52100 steel rings and 51100 steel balls. Test results for vacuum-melted Halmo steel are also shown.

Each line plot represents fifty 3206 Conrad-type bearings. Test conditions for the air-melted steels included heavy radial overloads of 1580 lb, 2000 rpm inner-ring rotation, 130 F bearing outer-ring temperature, and jet oil lubrication with Esstic No. 65 oil. The vacuum-melted steels were tested under identical conditions with the exception that for the Halmo steel the lubricant was MIL-L-7808, oil inlet temperature was 350 F, and bearing components' temperature was 400 F.

Bearing failure is a spalling of race surface detected by increased vibration or increased noise level. Note that all the air-melted bearings show approximately the same degree of early failure as indicated by hours endurance and approximately the same scatter pattern as indicated by line slope. Also note the tremendous gain in first-failure life achieved by vacuum melting.

All the induction-vacuum-melted bearings were made from 300-lb ingots which passed incoming inspection specifications for cleanliness and chemistry. These test results recommend induction-vacuum-melted materials for bearings requiring maximum freedom from early failure. Difficulties exist, however, in processing steel which will pass inspection for nonmetallic inclusions. Examinations indicate that current induction-vacuum-melted materials supplied for antifriction bearing usage is, in general, very clean, but some portions are contaminated with ceramics from furnace liner or launderer. Currently, there is no means of detecting these defects either in the bar stock or finished product if the defect is totally below the surface.

These contaminated areas, if in heavily stressed

SERVING on the panel on vacuum-melted metals were:

R. F. Thomson, panel chairman
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H. C. Rezeau, Jr., panel secretary
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E. D. Marande
Ford Motor Co.

A. M. Aksoy
Vacuum Metals Corp.

W. R. Kiessel
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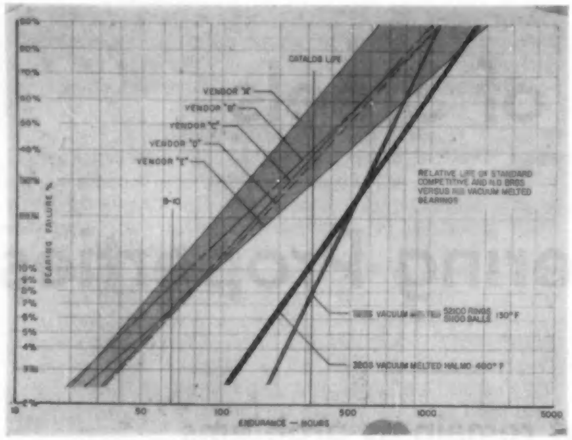


Fig. 1—Vacuum-melted bearings show longer life than air-melted bearings.

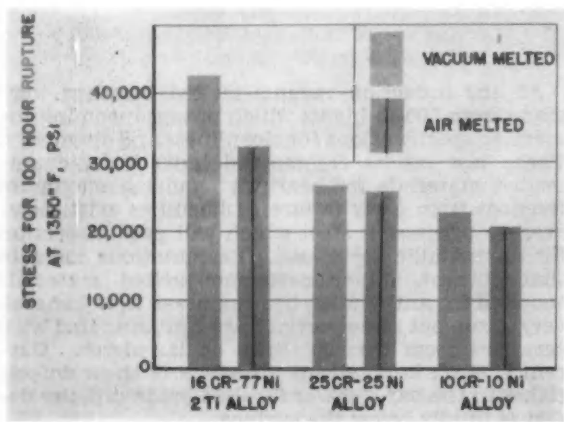


Fig. 2—Vacuum melting increases the stress rupture life of high nickel titanium alloy by approximately 30%. The improvement, however, is believed to be related to the presence of titanium.

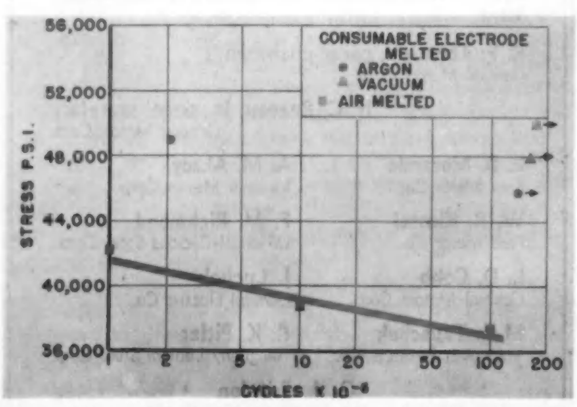


Fig. 3—Fatigue data indicate that the exclusion of air alone does much to increase the fatigue properties of 15 Cr-25 Ni-2 Ti steel at 1200 F.

locations, cause very early bearing failures as found in destruction inspection after test. Nondestructive inspection is being worked on, but is currently not feasible for usage on the small size inclusions we are concerned with. This contamination problem is well known to material producers and has led to research to overcome this deficiency and gives promise of being overcome. The problem has also led into the exploration of various means of using the good characteristics of vacuum melting with elimination of the need for lining materials by such processes as consumable electrode or zone melting in vacuums.

Valve and Stainless Steels

Whether or not to vacuum melt the stainless steels and valve alloys is currently an open question. These alloys ordinarily find their way into highly competitive applications, and thus the question resolves itself into one of engineering desirability on the one hand and economic justification on the other. Vacuum melting has not found many applications in the field of valve and stainless alloys, but the process possesses inherent advantages which may lead to its adoption for these alloys in the not-too-distant future.

The potential advantages of vacuum melting from the standpoint of the metal processor fall into roughly two classifications—those relating to improvements in engineering properties of the alloy, and those relating to improvements in workability or formability. Under improvement in mechanical properties we can list fatigue, creep strength, impact, and such. Also, since all stainless and valve alloys are designed primarily for corrosion resistance, we can list potential improvements in corrosion resistance as a separate advantage. Improvements in workability can be subdivided into those relating to forming limits and those relating to alloy limits. Here forming limits pertain to the maximum amount of shaping or forming that can be done on an alloy during a typical forging or similar operation and alloy limits refer to the maximum and minimum chemical analyses that can be handled during such operations.

It is reasonable to assume that vacuum melting by itself will not have too much effect on properties such as tensile, yield, and so on, but will have a pronounced effect on properties relating to notch effects, principally fatigue and impact. There is also evidence that indicates vacuum melting will increase the stress rupture life of typical valve alloys. Fig. 2 shows stress rupture data developed on three analyses covering the current range of valve alloys. There is approximately 30% improvement in the stress rupture life of the high-nickel titanium alloy. This is a titanium-hardened material and the improvement is believed to be related to the presence of titanium. With the other two commercial valve alloys, the improvements are so small as to lack significance and certainly do not in themselves justify the use of vacuum melting.

We have not yet had an opportunity to develop sufficient elevated-temperature fatigue data on valve alloys to determine the effect of vacuum melting on this property. There is considerable literature showing substantial increases in fatigue resistance at room temperature and it is anticipated

that these improvements will carry over to elevated temperatures.

Fig. 3 shows some scattered fatigue data obtained on a 25 Ni-15 Cr titanium-hardened alloy at 1200 F. These data were obtained on consumable-electrode remelted material, both under Argon and in vacuum, and the data indicate that most of the improvement can be obtained by the exclusion of air alone. Again, it should be pointed out that this is a titanium-bearing alloy and that the improvement in fatigue resistance of the consumable electrode remelted material is probably due to the absence of titanium stringers.

Fig. 4 shows additional data on the same alloy comparing Argon-melted and vacuum-melted material. These data show that the use of vacuum reresults in a further improvement in fatigue which, while not as large as that obtained through the exclusion of air, is significant nevertheless. Since the use of Argon would effectively preclude the presence of complex titanium compounds, it can be reasoned that the magnitude of improvement shown in Fig. 4 is roughly the same as that to be expected with a more conventional titanium-free alloy.

One very significant property of stainless and valve alloys that can be influenced by vacuum melting is corrosion resistance. Fig. 5 shows some early data obtained on three analyses comparing the corrosion resistance of air-melted and vacuum-melted materials in a laboratory test. These data show that with the two high-alloy materials the corrosion resistance is only slightly improved. On the other hand, the low-alloy material shows a pronounced improvement with vacuum melting and one which brings its corrosion rate down to a level comparable to current austenitic valve alloys containing considerably higher alloy percentages. The reason for this improvement is not apparent. It is possible that trace contaminants dispersed through the melt form tiny galvanic cells which cause pitting-type corrosion in the air-melted analyses. However, pitting-type corrosion has been encountered with the higher alloy materials when run with vacuum melting. Those materials with inherently poor corrosion resistance may be more susceptible to intergranular galvanic-type corrosion and thus respond more readily to the removal of volatile contaminents by vacuum melting.

Corrosion data similar to that shown in Fig. 5 have been run on most of the conventional valve analyses using the consumable-electrode remelt process under vacuum. Without exception, these tests have shown only minor changes in the corrosion resistance. The data in Fig. 5 were obtained from induction-melted materials and the question naturally arose as to whether the consumable-electrode process was effectively removing the corrosion-inducing elements. A 14 Cr-14 Ni alloy was therefore singled out and tested all three ways; air melted, induction melted under vacuum, and remelted by consumable electrode under vacuum. Again, laboratory tests showed only minor changes in the corrosion rate.

The more significant advantages of vacuum-melted material lie in the area of workability during manufacture. Fig. 6 shows a particularly severe forming operation used to make hollow-head aircraft valves. In this process, a billet cut from a bar is first pierced to form a can, which, through a series

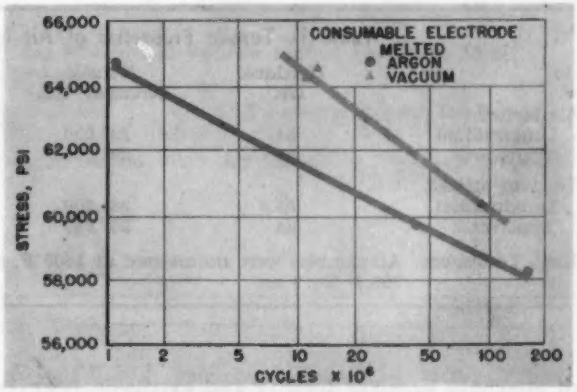


Fig. 4—The use of vacuum results in a further improvement in fatigue which while not as large as that obtained through the exclusion of air, is significant nevertheless.

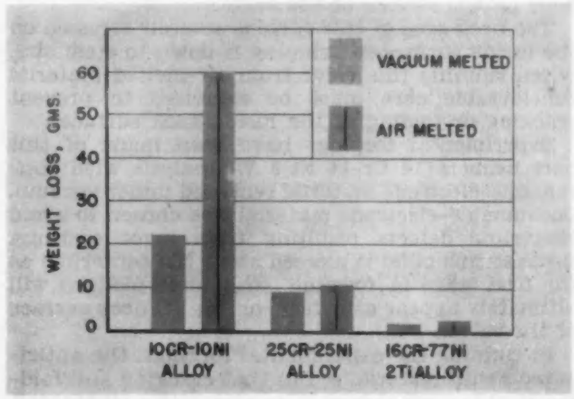


Fig. 5—Comparison of the corrosion resistance of air-melted and vacuum-melted alloys.

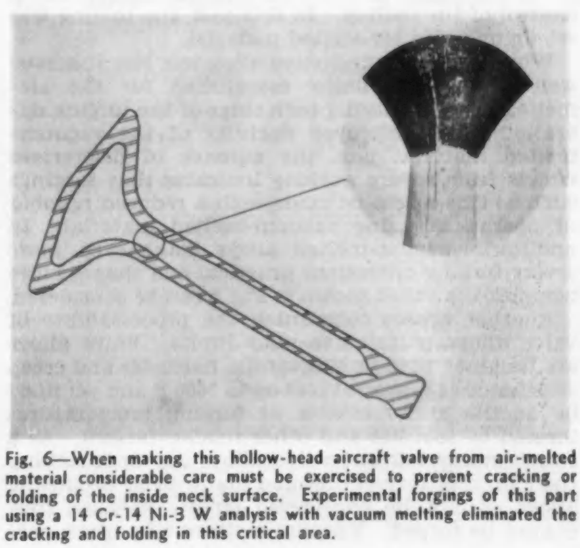


Fig. 6—When making this hollow-head aircraft valve from air-melted material considerable care must be exercised to prevent cracking or folding of the inside neck surface. Experimental forgings of this part using a 14 Cr-14 Ni-3 W analysis with vacuum melting eliminated the cracking and folding in this critical area.

Table 1—Tensile Properties of Air Melted and Vacuum Melted 4340 Steel

	Hardness (RC)	Tensile Strength (psi)	Yield Strength 0.2% Offset (psi)	Elongation in 2.0 in. (%)	Reduction of Area (%)
Air Melted					
Longitudinal	54	290,000	222,500	10.5	35
Transverse	54	288,500	221,000	5	17
Vacuum Melted					
Longitudinal	53.5	285,000	215,000	12	41
Transverse	54	287,000	222,000	10.5	40

Heat Treatment: All samples were normalized at 1600 F, austentized at 1500 F for 2 hr, oil quenched, and tempered at 350 F for 2 hr.

of alternate hammer forging and extrusion operations, is formed into the finished valve forging. The internal shape of the head cavity is held to close limits and after the hammer forge and extrude operations begin, can no longer be reached from outside the valve for machining purposes. The shape of this cavity is controlled by the amount of work done on the outside of the valve.

The neck area of this valve is severely stressed on the inside surface in bringing it down to stem size. When running this valve from air-melted material considerable care must be exercised to prevent cracking or folding of the inside neck surface.

Experimental forgings have been made of this part using a 14 Cr-14 Ni-3 W analysis with consumable-electrode material remelted under vacuum. Consumable-electrode material was chosen to avoid centerline defects resulting from ingot castings. Because this billet is pierced along the centerline as the first stage in forming, such imperfections will ultimately appear as defects on the ID neck surface of the valve.

In running the experimental forgings, the anticipated result materialized in that cracking and folding in this critical area were completely eliminated. An unanticipated result also occurred in that the vacuum-melted material appeared to be considerably more ductile in forging than air-melt material. In each forging operation, the internal cavity surface is brought to a predetermined dimension by control of the tooling. In this test, the tooling was set up by using air-melted material.

When the vacuum-melted alloy was run it moved well beyond the limits established for the air-melted material during each stage of the forging operation. The improved ductility of the vacuum-melted material plus the absence of deleterious effects from severe working indicates that forgings such as this might be made with a reduced number of operations using vacuum-melted material. In addition, vacuum-melted alloys make even more severe forging operations practical and shapes more complex than that shown in Fig. 6 can be considered.

Another aspect concerning the processability of valve alloys pertains to alloy limits. Valve alloys are designed to have substantial hardness and creep resistance at temperatures up to 1600 F and yet must be ductile and formable at forging temperatures limited by tool life and other related factors. As a result, many current valve alloys are approaching their limit of formability and many other promising alloys cannot be considered simply because they cannot be forged. Vacuum melting very often permits alloy concentration limits to be increased and also permits entirely new alloys to be considered. An outstanding example of this is that of the iron-aluminum alloys which, in many respects, possess desirable valve properties. Iron-aluminum valves have been engine tested with reasonable success and while certainly further improvements are necessary before they can be considered as valve alloys, the opportunity to use this or similar alloy systems is available through vacuum melting.

Forming iron-aluminum alloys through conventional forging processes with air-melted material is out of the question. The presence of dispersed aluminum oxides makes these alloys so brittle that they cannot be shaped into a valve. Yet using vacuum-melted material we have had no problems in forming iron-aluminum valves using conventional production forging equipment.

There are real and potential advantages to vacuum-melted material, particularly in the area of processing. So far these advantages have not been sufficient to offset the higher cost of vacuum-melted materials. Ultimately vacuum melting will probably find many applications in the areas of valve and stainless alloys. Before this can occur, however, there must be considerably more work, particularly in the area of alloy development, to take full advantage of the vacuum melting processes.

Low-Alloy Steels

Recent technological developments have increased the demands for new or improved alloys for critical applications. In the field of low-alloy steels, for example, aircraft design engineers are looking for steels which can be heat treated to the 260,000 to 300,000 psi strength level and yet have good ductility and impact properties. Others are constantly seeking steels with high fatigue and impact properties for numerous applications such as, valve tappet rollers, gears, bomb hooks, and gun parts.

It has now been established that substantial improvements in mechanical properties of certain metals and alloys result from vacuum-melting techniques. In the case of low-alloy steels, significant improvements have been obtained in transverse mechanical properties and fatigue strength.

In general, the limiting value of useful strength for aircraft steels will depend upon transverse properties rather than longitudinal properties. Data obtained by a number of investigators seem to indicate that alloy steels melted conventionally possess

Table 2—Room Temperature Impact Properties of Air Melted and Vacuum Melted Low Alloy Steels (V-Notch Charpy)

Steel	Hardness (RC)	Longitudinal Impact Energy (ft-lb)		Transverse Impact Energy (ft-lb)	
		Air Melted	Vacuum Melted	Air Melted	Vacuum Melted
4340	46–47	16	19	—	12
4340	52–54	18	21	9	14
UHS 260	52–54	15	22	7	11
9310	37–39	45	100	14	51

very low transverse ductility and notch toughness. However, there is evidence that transverse properties of vacuum-melted alloy steels approach more closely the longitudinal properties.

The tensile properties of vacuum melted and air melted 4340 steel heat treated to 290,000 psi strength level are given in Table 1. There is little difference in the longitudinal tensile properties, but the vacuum-melted material shows higher ductility in the transverse direction than does the air melted 4340. In Fig. 7, longitudinal and transverse tensile ductility of vacuum-melted 4340 steel at various strength levels is further compared with that of air-melted alloy. These data indicate that vacuum-melted materials have very little tendency to develop directionality.

Notch sensitivity is an excellent index of the toughness characteristics of a material under any type of loading. In Fig. 8, longitudinal and transverse notched tensile strengths of Ferrovac 4340 are compared with those reported for air-melted material. These data clearly indicate that the notched strength of vacuum-melted steel is considerably higher, with no significant difference between longitudinal and transverse values. The indications are that the results obtained on vacuum-melted 4340 holds true for other high-strength steels.

The increased tensile ductility observed in vacuum-melted low-alloy steels is particularly evident at high strain rates, as in the case of impact test. V-notch Charpy impact properties of various low alloy steels at room temperature are shown in Table 2. Vacuum-melted steels exhibit consistently higher impact energy than do the air-melted steels in both longitudinal and transverse directions.

The longitudinal fatigue limits of vacuum-melted and air-melted 4340 are plotted as a function of tensile strength in Fig. 8. The curve for the vacuum-melted steel is considerably higher with no falling off up to the 290,000 psi strength level.

The foregoing results were obtained on a limited number of production heats, but they are being supplemented by work performed at several laboratories. As the number of heats tested increases, it will be possible to make a statistical evaluation of the results. Based on experience with other alloys however, the variation in mechanical properties of vacuum-melted steels from heat to heat or within the same heat is small when compared with those found in air-melted material.

(This abridgment is based on secretary's report of a panel entitled "Vacuum-Melted Metals—How They Can Help the Designer.")

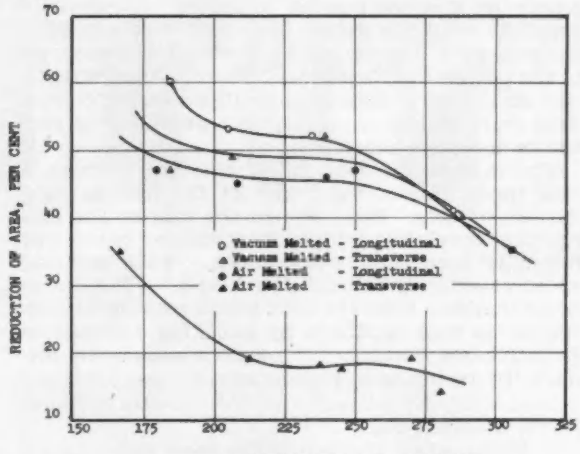


Fig. 7—Comparing the longitudinal and transverse tensile ductility of vacuum-melted 4340 steel with that of the air-melted alloy indicates that the vacuum-melted materials have very little tendency to develop directionality.

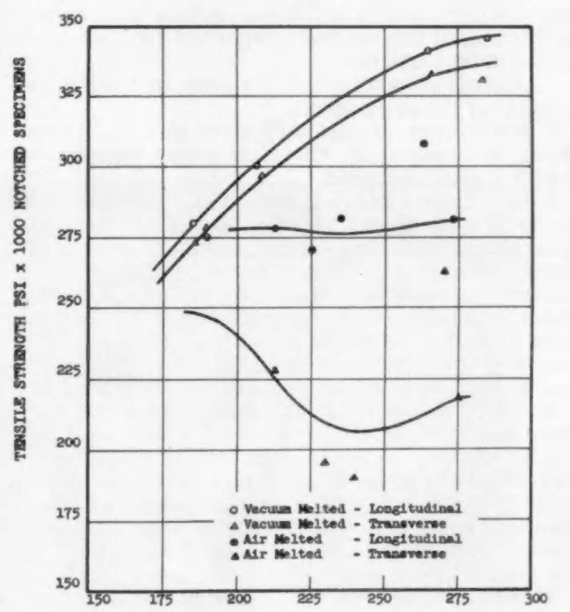


Fig. 8—The notched tensile strength of vacuum-melted Ferrovac 4340 is considerably higher than the air-melted alloy, with little difference between longitudinal and transverse values.

Here's some light on why

Hot High-Compression Engines

MORE torque is often required to start high-compression gasoline engines when they are hot than when they are cold. In these cases, investigation shows, compression ignition occurs at isolated points in the combustion chamber. Combustion proceeds normally from these points of abnormal ignition until a second type of reaction is observed in the last part of the charge to burn. The combination of the early abnormal ignitions and the rapid final reaction can cause cylinder pressures to peak before top dead center.

The rate of the final rapid reaction is three to four times greater than that of the normal combustion process. Even though the rate of the final reaction is relatively high, it is still far below that normally associated with knock. This medium-speed reaction is called "slow knock." The engine noise resulting from the slow knock reaction is quite similar to that produced by knocking combustion. In both cases vibrating engine parts apparently produce the resulting engine noise.

Laboratory investigation of the hot-starting phenomena shows that:

1. Compression ignition is the basic cause.
2. Deposit-induced surface ignition is not involved.
3. Highly luminous spots appear in the burned gas region. These spots are characteristic of explosions initiated by compression ignition and they increase in number as the severity of the hot-starting phenomena increases. They do not appear to be caused by burning of incompletely vaporized fuel, oil droplets, or dust particles.
4. Antiknock quality can be used to control the severity of the phenomena.
5. Regardless of fuel antiknock quality, normal knock is replaced by the slow knock reaction at engine cranking speeds.
6. Primary reference fuels are considerably more prone to compression ignition than other pure hydrocarbons, such as benzene, diisobutylene, or toluene, blended to give the same Research octane number. Commercial fuels of the same Research octane level are also better than the primary reference fuels in this respect.
7. The severity of the phenomena increases with engine compression ratio and coolant temperature.
8. The most severe air-fuel ratio is that for maximum power.
9. Complete control of the combustion process can be maintained if the spark advance is very early or very late. (In tests with isooctane under standard hot-starting conditions at 9/1 compression ratio, spark advance had to be earlier than 48 deg btc or later than 18 deg atc.)
10. Compression-ignition severity is affected by intake manifold air pressure. (In the tests, over a range of intake manifold air pressures of 20-38 in. of Hg absolute, the severity of compression ignition increased linearly with the pressure.)

Flame photographs and corresponding pressure record (shown at right) . . .

. . . of a typical explosion occurring when 70-octane primary reference fuel was used under standard hot-starting conditions.

Photographs were taken in standard ASTM-CFR single-cylinder knock test engine modified to accommodate a full quartz window. Hot-starting conditions used: 6.75/1 compression ratio, 150 rpm, 190 F coolant temperature, 180 F oil temperature, wide-open throttle, tdc spark advance, 10% rich air-fuel ratio.

Note that initial ignitions occurred over the intake valve in two different areas at 14 deg btc. Additional areas of ignition occurred as combustion proceeded.

Spatial rate of flame propagation from the ignition centers was about 25 fps, which is considered normal for an engine speed of 150 rpm.

The photographs show further that the slow knock reaction began at 8-9 deg btc and completed the combustion process at 6-7 deg btc.

The pressure record also indicates the effects of this abnormal explosion. For example, it shows the effects of the higher rate of reaction that started at 8–9 deg btc and shows peak cylinder pressure occurring at the completion of the combustion process at 6-7 deg btc. Rate of pressure rise was so rapid that the trace appears almost vertical and can barely be seen, due to the low film exposure for this section of the pressure record. The pressure decrease, which occurred after combustion was complete despite the continued minor piston compression, may be attributed to heat loss and gas leakage.

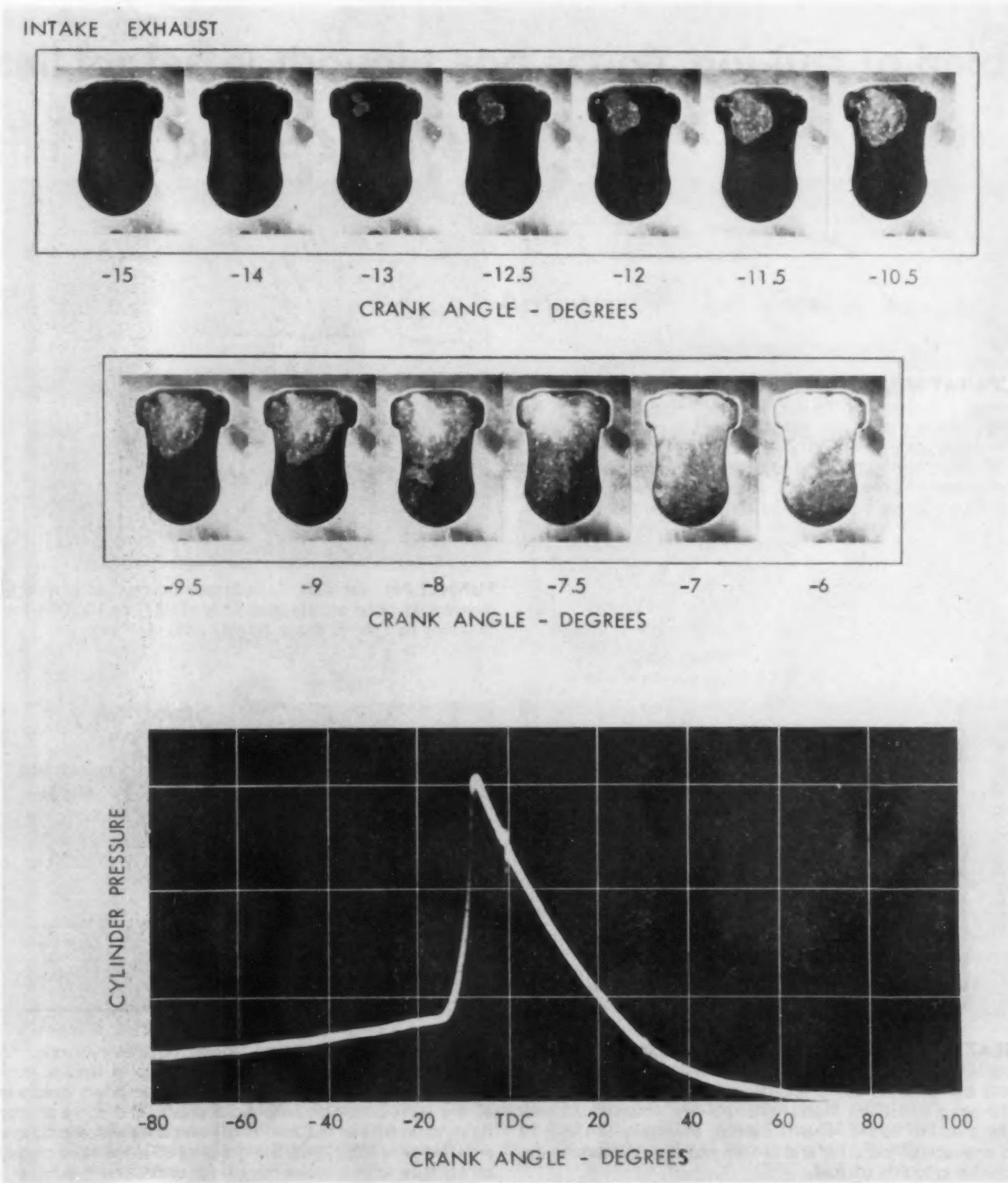
Even though the total work of the cycle may be zero, as it was in this case, an automobile starter cranking an engine under these conditions would be required to furnish extra torque in order to turn the engine the last 20 deg of the compression stroke. Hence, the starter requirement would be increased and the reason for starter stalling is apparent.

Flame photographs showing the compression-ignition and slow knock phenomena, together with the resulting pressure card, are shown in the accompanying figure.

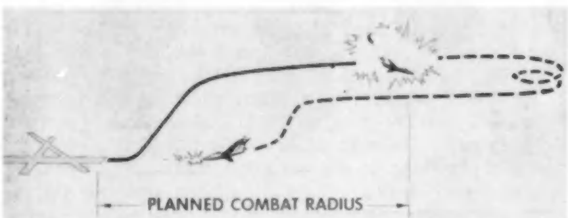
(Paper, "Autoignition Associated with Hot Starting," on which this abridgment is based, is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Based on paper by **Fred W. Bowditch and Russell F. Stebar,** Research Staff, GMC

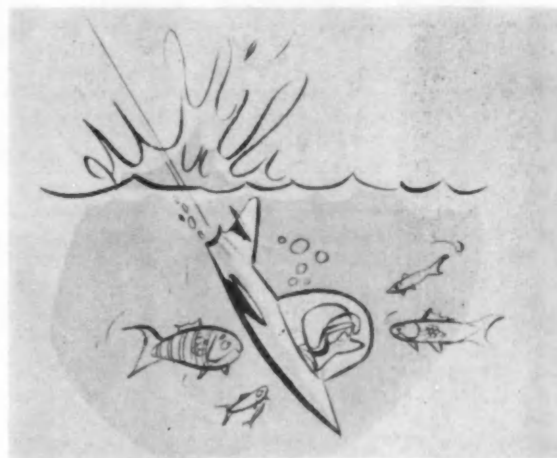
Start Harder than Cold Ones



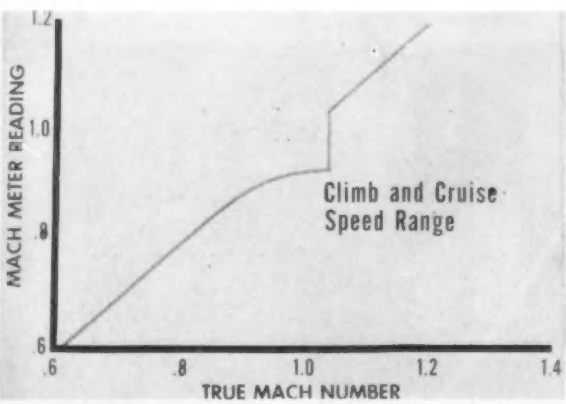
Supersonic Flying . . .



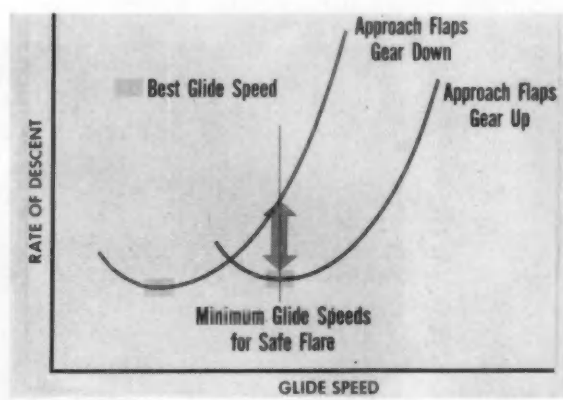
COMBAT MISSION with supersonic fighter. Nothing new about it except that the aircraft goes twice as fast and for that reason a pilot can get into trouble twice as easily if he doesn't pay attention. Five minutes of chasing will add 100 miles to the radius and the results are obvious. Add even two minutes to combat time and you can't get home, or if you do you'll probably be coming in on the fumes.



FUNNY? No, just fact. A supersonic aircraft in a vertical dive would close on the ground at 50,000 to 100,000 fps. It leaves no time or space to play around.



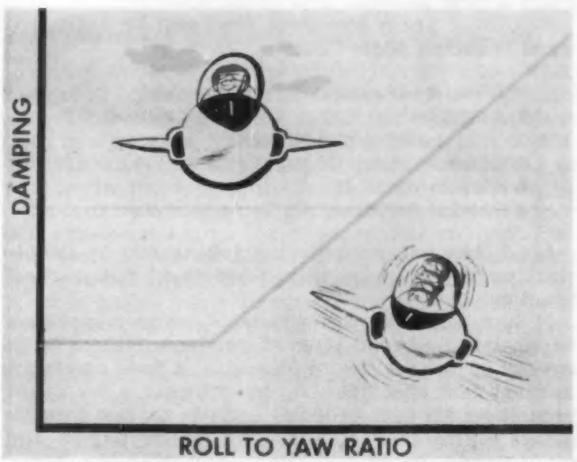
BLAZING SPEED characterizes new supersonic fighters yet 90% of the time in the air is spent at half speed. Cruise and low-altitude climb speeds unfortunately fall right at the point where the Mach meter position error occurs near the speed of sound. This is serious, especially if the pilot is unaware of the error and cruises too fast, consuming excessive amounts of fuel.



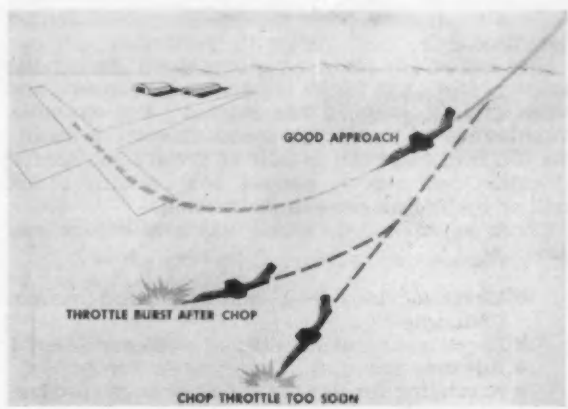
DEAD ENGINE descent and landing puzzles everyone. An airplane is at its worst lift-over-drag ratio in landing configuration. The curve on the left must be flown precisely at the right condition to avoid a crash. The curve on the right represents an increase in lift over drag which produces a flatter glide slope, enabling the pilot to judge more closely on his flare with a wider margin for error.

. . . is just dandy. Pilot stress and strain go up in direct ratio to speed and altitude. New planes call for faster thought and action, not just to hold the job, but to survive.

Based on paper by **Anthony W. Le Vier,** Lockheed Aircraft Corp.



OSCILLATIONS have always plagued us but most of them have been acceptable because of their long period. With supersonic planes there can be excessive rolling due to yaw and the period too short for the pilot's sensory system to cope with. New aircraft must have their own sensory system capable of sensing minute angular motions about all three axes and tied to the power flight control system. Then the pilot can have a smoother ride than in a transport.



LANDING CONFIGURATION of a supersonic fighter is best described as a "streamlined brick." That's the reason why a straight-in approach is better than a turning one. In a turning approach, reserve energy is being wasted to turn instead of roundout, or flare, for a landing. With the advent of the jet, approach and landing problems were multiplied ten-fold. Because the jet engine is very inefficient at low rpm's, it is imperative to maintain high rpm on all approaches until a safe landing is assured. Improper use of the jet engine during approaches has accounted for about 50% of all jet aircraft accidents, and there is no reason why the supersonic airplane should be an exception.

(Paper, "Flight Testing and Flying Techniques of High-Altitude Supersonic Aircraft" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Many areas offer

Opportunities For

POTENTIAL areas for shortening the lead-time cycle in the development and production of weapons systems include:

1. Proposal.
2. Engineering.
3. Procurement.
4. Tooling.
5. Fabrication.
6. Testing.

Although little can be done during the proposal stage to directly reduce the lead-time cycle, thorough preplanning will result in a more realistic program and disclose potential areas for shortening flow times.

The amount of planning effort spent during the proposal stage will lessen unnecessary problems and pains after a program has started. For example, troublesome and unknown items discovered during the proposal stage can usually be given some special attention and quickly carried out avoiding a fire drill or costly flow time in production.

Other considerations which may help reduce lead time are:

- Checking long-lead materials and vendor items.
- Investigating availability of skills and talents.
- Advance spending of contractor funds.
- Arranging for limited funds to do preproduction work.
- Investigating the flow time required by associate contractors.
- Minimizing customer approval necessary prior to placing subcontracts and procurement ment orders.

Engineering

During the design and development phase of engineering, several steps can be taken to reduce the lead-time cycle. First, prime responsibility should be given to the design engineer, with other division representatives participating on an advance basis. Second, simplified drafting practices should be employed when possible and advance releases made whenever practical. Greater participation by tooling, procurement, and fabrication well help considerably to make this work smooth and satisfactory.

When the program reaches the production engineering phase, the production engineer should assume control and coordinate with other divisions. Important to the success of this phase of the program are the orderly release of advanced data and proper control over engineering schedule and expenditure. Without proper follow-up, the program can easily get off par and it becomes almost impossible to recover and get back on schedule.

Procurement

The part played by procurement in shortening the lead-time cycle is a very broad one because it encompasses practically all the time required to place a new product into production.

Following are a few steps that can be taken toward reducing span times:

- Advance planners in engineering.
- Assist in preparing advance releases for materials and procurement.
- Consideration of substitutes.
- Standardization.
- Special handling for long-lead items.

Lead time can be materially shortened by simply starting negotiations with vendors at the earliest practical time.

It has been the experience of some companies, which handle broad lines of products with a large variety of parts and complications of final assembly, to meet test specifications by utilizing a team approach on all new products. With all key departments represented on the team, better liaison and contact can be maintained. For example, many engineering changes which normally would be made later, can be put in the original design because tooling and manufacturing representatives can make suggestions as engineering progresses.

Tooling

Shortening lead time in the tooling stage should first be considered when preplanning starts in the proposal stage. When the tooling ground rules are being set up, the following items should be carefully reviewed:

- Availability of qualified manpower.
- Master gage plan.
- Possibility of a subcontract program.
- Hour estimate for initial tooling
- Hour estimate for ultimate tooling.

Based on secretary's report by **E. C. Soistman,** Martin Orlando

Cutting Lead Time

Tooling planners should be assigned to engineering at the earliest possible time to assist in making advance releases. The planners must act as the manufacturing coordinators in engineering, insuring that all information is disseminated among the various manufacturing departments. All differences pertaining to design, tolerance, or material should be ironed out before release to the factory.

It is also most important that systems of controls and reports be established for management analysis to reflect program progress and to accentuate areas of weakness and strength which may affect the allotted tooling lead time.

Fabrication

Although much to the total span time has been expended by the time an item reaches the fabrication area, new methods, systems, and techniques used in operating, controlling, and managing within the fabrication shops can be productive areas to explore in shortening the lead-time cycle.

Advance planning enables fabrication to give special consideration to the development of plant layout, tooling, fabrication, and assembly plans which will reduce flow time to an economical minimum. At this point, many items having long or difficult lead-time problems in procuring or tooling are ferreted out and procurement, tool design, or tool fabrication are initiated using preliminary or partial engineering.

Development of work standards, manloading, and job cycling remove many reasons for work stoppages and provide better management control. In addition, every effort should be made to functionally and operationally check all individual components prior to installation at the earliest possible point in the assembly cycle.

Some of the most promising tools for further shortening lead-time cycles in fabrication lie in electronic data processing, material handling, and in numerical control. These three items will eventually make a substantial reduction in manpower, facilities, cost, and time spans.

Testing

There has been, and will continue to be, a tremendous increase in the amount of testing required for all elements of a weapons system. But, testing has become more and more complex with the time involved constantly on the increase.

In addition, the speeds and altitudes of aircraft and missiles are pushing into an environment where the very best extrapolations from basic scientific knowledge and scale laboratory work fail to predict and describe fully. Under these conditions, testing must serve a dual function: prove projected performance, and establish basic data covering the phenomena encountered. Also, both quality and time must be improved in accomplishing test requirements.

(This abridgment is based on secretary's report of panel "Shortening the Lead Time Cycle." The complete report, along with secretaries' reports of five other aeronautic production panels, is available as SP-319 from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: $1.50 to members: $3 to nonmembers.)

SERVING . . .

. . . on the panel which developed the information in this article were:

J. S. Mason, panel leader
Martin Orlando

E. C. Soistman, panel secretary
Martin Orlando

E. A. Starkey
Minneapolis Regulator Co.

M. F. McCammon
Bendix Aviation Corp.

C. W. Easton
Boeing Airplane Co.

M. A. Bigelow
Fairchild Engine and Airplane Corp.

Col. M. J. Wetzel, USAF
Air Materiel Command

3 Test fixtures provide . . .

Accelerated Testing of

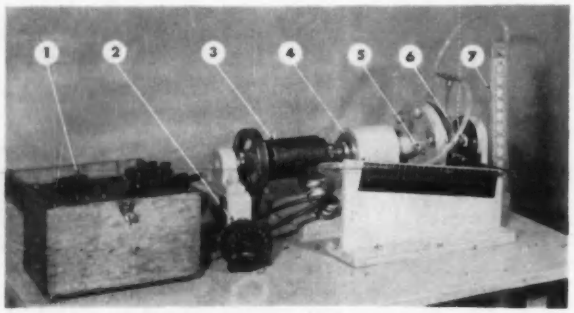


Fig. 1—Oil seal torque and leakage test fixture.

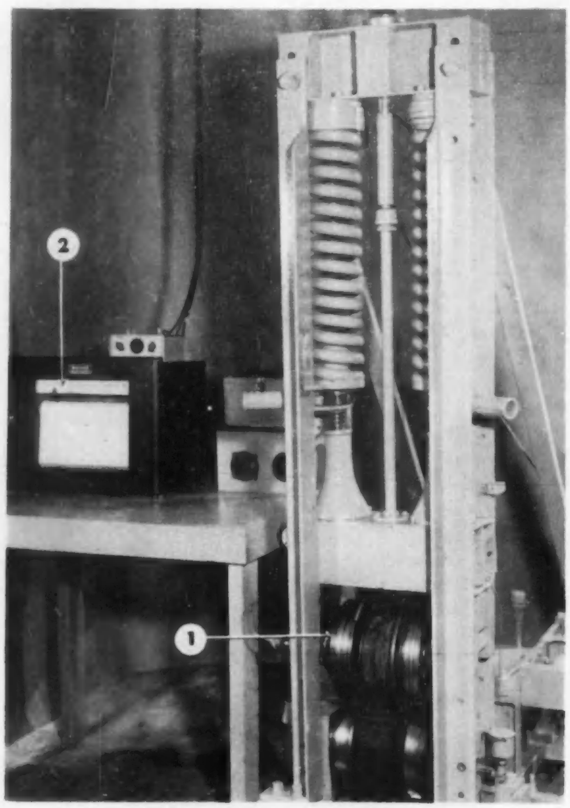


Fig. 2—Secondary oil seal test fixture.

INTERNATIONAL HARVESTER is using three types of fixtures for laboratory testing of crawler-tractor track-roller oil seals. The first fixture tests the seal for leakage. The second fixture simulates the various movements of a roller on a tractor. And the third fixture subjects the seal to an accelerated endurance test under the worst environmental conditions possible. A seal passing all three tests is pronounced fit for use.

The first fixture used in the progressive testing of a new track-roller oil seal tests the seal for leakage, determines the torque requirements of the seal at various unit pressures, determines the pressure buildup due to heat, and reveals the effects of this pressure on sealing ability. The compatibility of different types of face materials can also be readily ascertained with this device.

Seal surface temperatures are determined by three thermocouples located in the seal-drive flange [Fig. 1–(5)]. The thermocouple leads pass through the center of the drive shaft and past the drive-shaft bearings, where they emerge and are fastened to a mercury slip ring [Fig. 1–(3)]. A selector switch [Fig. 1–(2)] and a potentiometer [Fig. 1–(1)] complete the circuit.

An inclined sight gage [Fig. 1–(4)] enables the determination of leakage to within 1 or 2 cc.

Since different face materials have different coefficients of friction a torque-measuring device is included on the fixture [Fig. 1–(6)]. This torque pickup also acts as the mounting flange for the stationary part of the seal. Thus the torque readings are entirely divorced from any torque requirement of the fixture drive-shaft bearings. The strain gages are mounted on the tube of the pickup such that they are not affected by bending moments which may be imposed on the mounting flange. A water manometer [Fig. 1–(7)] is connected to the system to indicate the effects of temperature rise on pressure.

The base of the seal-mounting flange is readily adjustable so that it may accommodate seals of varying widths. Variation of unit pressure on the seal is accomplished by varying the operating height of the seal. The power for the test device is supplied by an electric motor which drives through a series of belts and a Reeves Drive, permitting the speed to be varied as desired.

The second stage of test for any given seal is performed on a track-roller test fixture (Fig. 2). This fixture was originally built for the testing of track-roller bearings, but it was pressed into service as a

Based on paper by **John L. Hildenbrand,** International Harvester Co.

Crawler-Tractor Oil Seals

portion of the seal-test procedure because it simulates, to a small degree, the various movements of a roller on a tractor.

The seals are installed on the special seal-test roller [Fig. 2-(1)] and then mounted in the fixture. This roller was originally a double-flange roller. The outer flanges were cut off so that the entire seal would be visible and the inner flanges were ground down to allow clearance for the drive chain. The drive roller is driven through a torque meter by a 15-hp electric motor. The operating torque is recorded continuously or periodically, as the tester desires, by the recording instrument [Fig. 2-(2)].

Load is applied to the test roller by means of the screw jacks pushing against the large load springs. Just enough load (4000-6000 lb) is applied to the roller to obtain a normal heat buildup and consequent pressure rise, such as would be obtained on a tractor.

This test can point out deficiencies such as too little clearance between parts where relative motion is required, or it may show weaknesses in gasketing on one or both sides of the seal. Leakage on this fixture is not measured but merely observed, and an effort made to determine its source. Once the source has been established the roller and seal can be disassembled and a closer inspection made to determine the deficiency.

The final stage of laboratory testing is done in the mud-box fixture (Fig. 3). After a seal has satisfactorily passed the first and second tests, which are of relatively short duration (24 hr), they are installed in the mud box. In this fixture they are brought to specified compressed operating width and rotating parts on the tractor are also rotating parts on the fixture. No effort is made, however, to protect the seal as it is protected on the tractor by the track-roller mounting bracket.

Up to four seals can be tested at one time on this fixture. The disconnect couplings on each drive shaft (see Fig. 3) make removal or installation of a box simple and quick. The graduated cylinders provide an accurate measure of oil-level change during the test. They are connected through the oil-seal-mounting flange into the cavity within the seal. Therefore, the only pressure on the seal is the slight head due to filling the cylinder half full. It has been found that failure of the seal faces usually results in an increase in oil level due to mud entry into the seal, whereas oil loss generally indicates failure of some other component of the seal.

The seals are run at a constant speed of 295-300 rpm. The direction of rotation is changed automatically every half hour for a period of 20 hr. The machine is then stopped for 4 hr to allow corrosive action to take place and to allow the seal and its components to cool to room temperature. This cycle is followed for 500 hr or until failure occurs, whichever is first.

The mud used in the test is a mixture of Phoenix dust and ordinary sand, with enough water added to make it the consistency of thick soup. Since operation in this mixture generates considerable heat, water is added to keep the consistency as uniform as possible.

This is an accelerated test. The abrasive environment is more severe than that found in the field, and it is, therefore, used as an evaluation test of seal-face materials.

Paper "Laboratory and Field Development of Oil Seals as Applied to Crawler Tractors" on which this abridgment is based is available in full in multilith form from SAE Special Publications Department, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

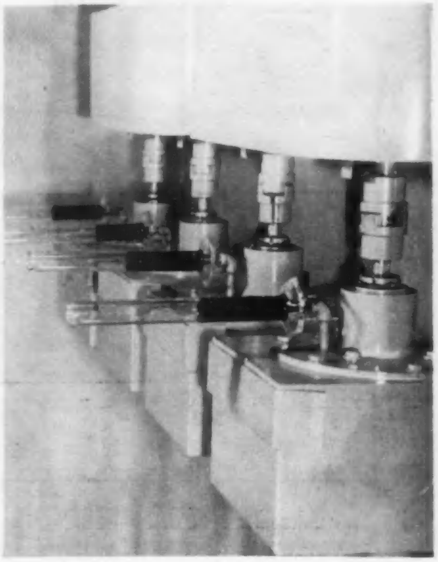
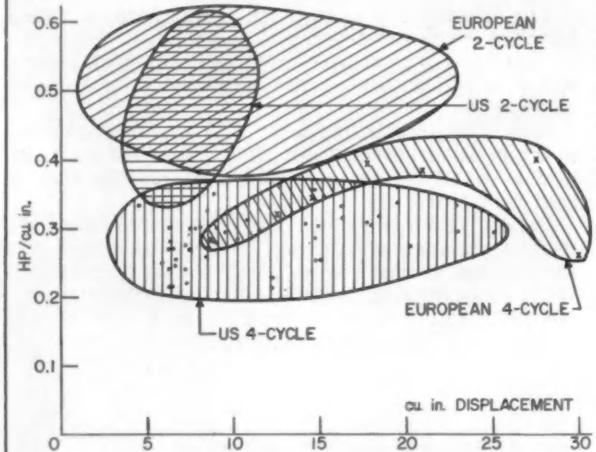


Fig. 3—Rear view of oil seal mud box fixture.

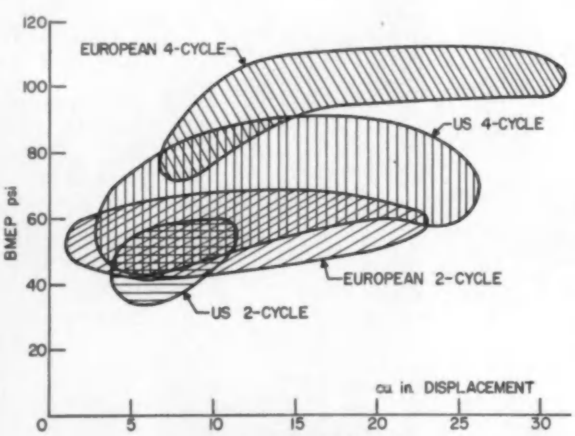
European Solutions of the Design of

Small

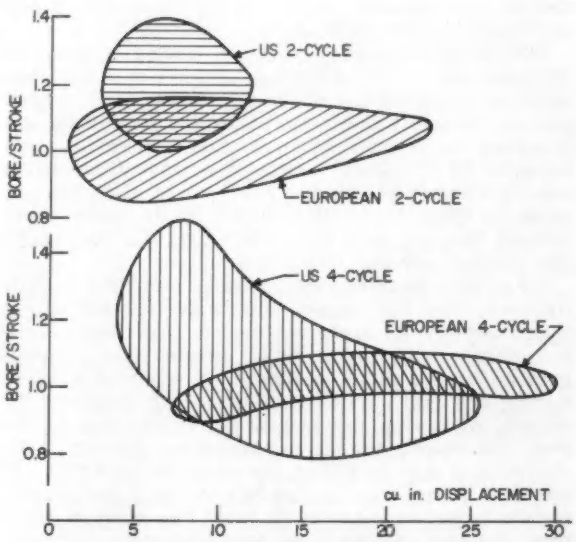
Comparison of European and U.S. Single Cylinder Gasoline Engines



Specific output



Rated BMEP



Bore/stroke ratio

ADAPTING motorcycle engines to industrial use has shaped the design of small European engines. Until recently there hasn't been enough industrial engine production to warrant specialized designs, such as the chain saw or lawn mower in this country. Geographical and economic differences will continue to demand designs differing with the U. S., but individual features may be transplanted.

Early electrification and high gasoline cost retarded the use of small gasoline engines and led to the development of high-speed light-weight diesel engines. Presently we have no diesel engines comparable to the Berning 4-cycle, 7-hp, 3000-rpm engine or a similar MWM engine. Also the luxury market of home lawnmower and rotary tillers, which accounts for a large volume in this country, does not exist in Europe.

For similar applications of gasoline engines some of the differences in design are:

- Built-up crankshafts—eliminates split con-

Based on a paper by **Prof. W. E. Meyer**, Pennsylvania State University

Aircooled Engines

necting rods, economizes on materials, cuts tooling costs for low volume production.

- Separate cylinder heads—simplifies cylinder machining, permits aluminum heads when costs require iron cylinders, eases carbon removal.
- Loop scavenging of 2-cycle engines—early piston burning troubles popularized this system since it eliminated the problem and permitted higher engine output.
- Three-port system—poor read valve performance on motorcycles lead to the third port.
- 1 :25 oil to gasoline ratio for 2-cycles—result of loop scavenging and extensive use of rolling contact bearings, ports stay cleaner longer.

Comparisons between weight, power, dimensions, and speed are shown on these pages.

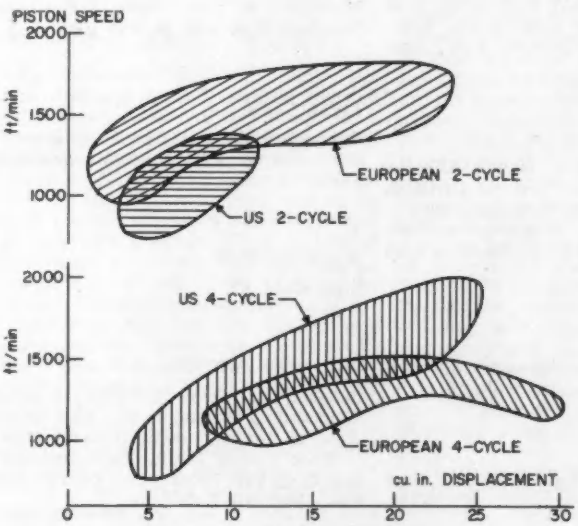
Diesel engines inherit the designs of their parent companies. They are scaled down 2- or 4-cycle engines with features similar to their big brothers.

Compression ratios range from 16 to 23 :1. Fuel economy catches up with high initial cost after approximately 500 hr of full throttle use. Starting is almost always by hand with a "pung" inserted in the cylinder to provide a starting flame.

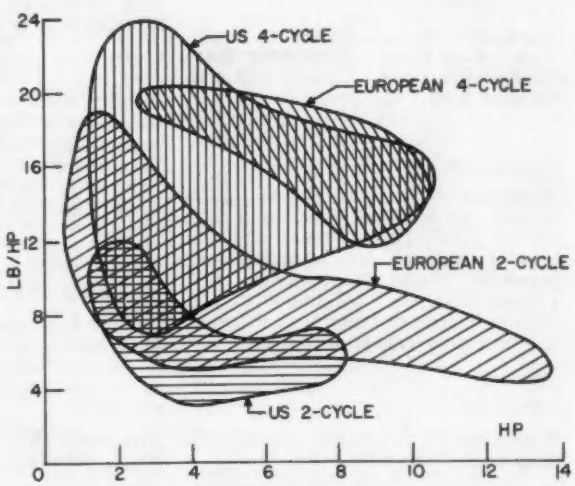
A comparison of techniques and objectives show:

- Torque curve characteristics are scrutinized in Europe because of extensive agricultural applications.
- European engines are heavy and rugged as owners expect long service and give good maintenance.
- Plating and spraying cylinders, as done in America, is almost unknown in production.
- Cold starting means continued cranking in Europe, there are few if any special starting devices.
- Roller and ball bearings are used extensively but hardly ever split, as they are in the U. S .
- Careful press fits are routine in Germany.

(Paper, "European Developments in Small Aircooled Engines," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)



Mean piston speeds



Specific weights

Section Meetings

BRITISH COLUMBIA

September 16 . . . Hotel Georgia. Dinner 6:30 p.m. Meeting 7:30 p.m.

CENTRAL ILLINOIS

September 16 . . . Harry E. Chesebrough, director of product planning, Chrysler Corp.—"Automotive Styling." Pere Marquette Hotel, Peoria, Ill. Dinner 6:30 p.m. Meeting 7:45 p.m.

CHICAGO

SOUTH BEND DIVISION. **September 16** . . . LaSalle Hotel, Bronzewood Room, South Bend, Ind. Dinner 6:45 p.m. Meeting 8:00 p.m.
October 8 . . . Neil L. Blume, director engineering, Special Products Division, Ford Motor Co., Dearborn, Michigan.—"The Edsel Story." Hotel Knickerbocker, Grand Ballroom, Chicago. Dinner 6:45 p.m. Meeting 8:00 p.m. Special Features: Social Half-Hour 6:15 p.m. to 6:45 p.m.

CINCINNATI

September 23 . . . Inspection Trip—Armco Steel Plant. Manchester Hotel. Middletown, Ohio. Dinner 6:30 p.m. Meeting 8:00 p.m.

CLEVELAND

September 16 . . . M. Kessler, G. S. Raeder and J. Weber, Fruehauf Trailer Plant, Avon, Ohio—"Truck Trailers, Special Trailers and Applications." Fruehauf Trailer Plant, Avon, Ohio. Dinner 5:30 p.m. Meeting 6:30 p.m. Special Features: Plant tour following meeting from 7:30 to 9:30 p.m.

DETROIT

September 30 . . . Junior Group Field Trip.

INDIANA

September 19 . . . H. C. Kirtland, chief engineer, Applications Transmission Operations, Allison Division, GMC., Indianapolis, Indiana. — "Automatic Transmissions in Heavy Duty Trucks." Indianapolis Naval Armory. Dinner 7:00 p.m. Meeting 8:00 p.m. Special Features: Slides to illustrate talk.

METROPOLITAN

October 10 . . . Fuels & Lubricants Dinner Meeting. John L. Sloop, chief, Rocket Engines Branch, Lewis Flight Propulsion Laboratory, National Advisory Committee for Aeronautics.—"Problems Involved in Lubricants and Fuels for Missiles and Satellites." The Brass Rail Restaurant, Fifth Avenue & 43rd Street, New York. Cocktail Hour 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

MID-MICHIGAN

October 7 . . . Small Cars—Pros and Cons. Oldsmobile Auditorium, Lansing, Michigan. Dinner 6:30 p.m. Meeting 8:00 p.m.

MILWAUKEE

October 4 . . . Neil L. Blume, director engineering, Special Products Division, Ford Motor Co., Dearborn, Michigan.—"The Edsel Story." Milwaukee Athletic Club. Dinner 6:30 p.m. Meeting 8:00 p.m.

MOHAWK-HUDSON

October 8 . . . Guest Speaker: Lothrop M. Forbush.

OREGON

September 19 . . . Carl Schnipell, west coast manager, Purolator Products, Inc., 3723 Wilshire Blvd., Studio 3B, Los Angeles, Calif.—"Air Filters." Imperial Hotel. Dinner 6:30 p.m. Meeting 8:00 p.m.

PHILADELPHIA

October 9 . . . Engineers Club. Dinner 6:30 p.m. Meeting 7:45 p.m.

SAN DIEGO

September 27 . . . President's Night. W. Paul Eddy, 1957 SAE President.

SOUTHERN NEW ENGLAND

October 8 . . . C. Branson Smith, Pratt & Whitney Aircraft Division, East Hartford, Conn.—"Missile Propulsion Systems." Bradley Field, Dinner 6:45 p.m. Meeting 8:00 p.m.

TEXAS

September 13 . . . Automotive Air Conditioning Meeting. Adolphus Hotel, Dallas. Beginning with registration at 8:00 a.m. Meetings from 9:00 a.m. to 10:30 p.m. Cocktail Hour 6:00 p.m. Dinner 7:30 p.m. Special Feature: Exhibits.

TEXAS GULF COAST

September 13 . . . Speaker from Thompson Products, Inc.—"Diesel Engines." Valian's. Dinner 6:45 p.m. Meeting 7:45 p.m. Special Features: Cocktails 6:00 p.m. to 6:45 p.m.

TWIN CITY

September 18 . . . Hasty Tasty Restaurant. Dinner 6:45 p.m. Meeting 8:00 p.m.

WASHINGTON

September 17.

WESTERN MICHIGAN

October 1 . . . Gregory Flynn, Jr., head, Mechanical Development Department, General Motors Research Staff, GMC. —"Free Piston Engine Development." Doo Drop Inn, Muskegon. Dinner 7:00 p.m. Meeting 8:00 p.m.

SECTIONS

SEPTEMBER 1957

Members Serve as "Mr. SAE" In 55 Detroit Plant Locations

The SAE Detroit Section Company Representative Committee has played an important role in Detroit Section membership development for many years. The Committee is composed of 57 SAE members who work at 55 plant locations in the Section area. The criteria for establishing an SAE representative in a given plant is that a minimum of 15 members are employed there.

Appointments to the Committee are made yearly by the incoming Company Representative Committee chairman and many of the present members have served for a number of years.

During recent years, a practice has been made of clearing a new appointment to the Committee with the engineering department head. This has been done to make certain the superior has an understanding of the SAE duties being assigned and to assure his cooperation. Further, the department head helps to select the proper man for the appointment and this, of course, engages company support for the SAE program. Popular, live-wire, and progressing engineers are the types most desirable for Committee work.

The Detroit Section office calls upon the Company Representative to handle various SAE matters, since he acts as a local liaison with the membership in his plant. He is expected to be informed on current SAE events, policies, and facts about the Society both Section-wise and nationally. He is expected to stimulate interest and handle dinner reservations for forthcoming Section meetings, items important to the success of meetings. Those serving on the Committee have authority to appoint helpers in plant areas where it is difficult for one man to cover the large group of SAE members and prospects. In short, the purpose is to build up the Representative as "Mr. SAE" in the plant location.

A few weeks prior to each meeting, announcement posters and a Company Representative Bulletin are sent to the Committee, detailing plans for the meeting and stimulating Committee action. These Bulletins are prepared immediately following the Strategy Committee meeting in which all phases of a forthcoming Section meeting are discussed three or four weeks in advance.

The Company Representative Committee in Detroit also serves as the Section Membership Committee, guided by a Membership Chairman. The Membership Chairman is regularly in contact with the Committee on membership affairs by bulletin or telephone.

Two meetings of the Company Representative Committee are called during the Section year. The first organizational meeting is sponsored by the chairman of the Committee in September and the second meeting by the Membership chairman in February. At these meetings the expected duties of the Committee are discussed, the planned programs presented, and Section problems reviewed. These meetings also serve as liaison with the Governing Board, in that Committee members make suggestions for improvement in handling meetings, and discuss types of programs which have maximum membership interest. Recommendations from the meetings are transmitted to proper representation on the Governing Boards.

New England Section Visits U.S.S. Wasp

Seventy-eight members from the New England Section recently boarded the aircraft carrier, U.S.S. Wasp, for a trip to sea to watch various operations and maneuvers.

The SAE group was given a complete tour of the ship and then treated to seeing a new squadron make their first flights from a carrier. After movies of historical naval battles, the Boston group saw another "first," that of the carrier refueling another ship at sea.

Luncheon was served in the Officers' Mess and the balance of the day was spent observing other sizes and types of planes practicing their take-offs and landings. On the homeward trip the engineers watched the crew members and a Marine detachment in their dress uniforms standing inspection.

The U.S.S. Wasp consists of 40,000 tons of steel and has a crew of 1700 men. The flight deck is 879 feet and the ship has a capacity of more than 85 aircraft.

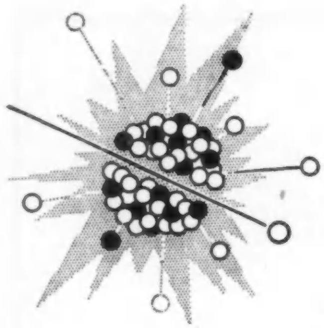
3 Sections Double Members in 5 Years

In the past five years SAE paid membership has increased 36%. Three Sections have more than doubled in size—San Diego is up 149%; Central Illinois is up 114%; and Atlanta is up 109%.

Thirteen other Sections that have equalled or bettered the Society's rate of growth are rated as follows:

Texas*	78%
Mid-Michigan	62%
Montreal	62%
Detroit	60%
New England	59%
So. California	53%
Twin City	51%
Colorado	51%
No. California	40%
So. New England	38%
Kansas City	38%
Cincinnati	37%
Indiana	36%

* The Texas Section has, since 1952, been divided into Texas Gulf Coast and South Texas, in addition to the Texas Section. The above tabulation is a combination of the three parts.



NUCLEAR NEWS NOTES

reported by SAE Nuclear Energy Advisory Committee

Cutrate Radioisotopes Will Bring Better Products

THE automotive—among many other—industries should benefit from the $2 million plant rising at Oak Ridge to process atomic waste into cheap radioisotopes.

This plant will be the first to extract isotopes from reactor wastes on a large scale. So far, most of them have been produced by thrusting small batches of nonradioactive elements into a reactor, thus making them "hot."

The new plant will take radioactive waste, in liquid form, from the nation's atomic reactors—coming from as far away as the Hanford plutonium plant in the state of Washington. It will arrive at the plant in huge lead drums resembling deep sea diving belts, riding on railroad flatcars or flatbed trucks.

This liquid will be pumped directly into tanks of the fission products separation plant. There it will be chemically treated to remove the useful isotopes.

When the plant begins full-scale operations early next year it will concentrate on producing cesium 137 (although later it is expected to branch out to produce other isotopes as well).

It wasn't long ago that Cs 137 was selling for $100 per curie. Today it costs about $14. With the new facility, AEC expects the price to drop to between $5 and $1 per curie.

Cs 137 has a half-life of 33 years. For many applications it will probably replace cobalt 60, which has a half-life of only 5.2 years.

Money Saved

The availability of cheap radioisotopes has a big dollars and cents meaning for business. Currently, industry and agriculture are estimated to be saving $500 million a year by using them. According to Dr. Willard F. Libby, AEC commissioner, this saving will jump to $5 billion annually by 1960–1962.

How Radioisotopes Are Used

The number of firms using radioisotopes has increased from 800 in 1953 to 1500 at the start of this year. These firms are using them in three general ways:

1. Gaging and inspection.
2. Tracing.
3. Irradiation of materials.

Gaging and Inspection

Radiation thickness gages operate on the principle that the thicker the material, the less the radiation that can seep through and be picked up by a counter. An incredible degree of accuracy can be achieved by this method.

With such gages Allegheny-Ludlum Steel Corp. can roll specialty steel so thin that it takes 10 sheets to equal the thickness of ordinary cellophane. The paper, steel, aluminum, plastics, and rubber industries have already largely replaced old methods of thickness gaging with these new devices.

Mass production of radioisotopes also is expected to increase sharply their use as a radiography tool. After passing through a material, such as an automobile part, the radiation is picked up by a photographic film. If any defects exist in the part, they show up on the film.

"Radioisotopes and equipment costing $3000," according to a Ford official, "will perform many of the functions of a $50,000 X-ray generator."

Atomic energy men expect the automation trend in dozens of industries to be speeded up by the wedding of isotope control devices to mechanical processes. Hot atoms are already performing such work in several applications.

"The merging of atomic and servomechanism techniques," says an official of Industrial Nucleonics of Columbus, Ohio, "has achieved process control for the first time in some of America's oldest industries.

Basically, in one of these systems, radiation gages note any slight devia-

Weather Is Key to Reactor Locator Severity

As reported by H. J. Comberg, member, SAE Nuclear Energy Advisory Committee

IT IS IMPOSSIBLE to predict the loss of property or life from a reactor accident that might occur at random. It is only possible, by analyzing the frequency of occurrence of different types of weather conditions, to make statements about probabilities.

This and lots more information that should prove helpful in determining the risk involved in locating a reactor plant at a given site is contained in two recent reports:

1. "Theoretical Possibilities and Consequences of Major Accidents in Large Nuclear Power Plants," by a staff group of the U.S. Atomic Energy Commission at Brookhaven National Laboratory. (Released in March, 1957.)

2. "Possible Effects on the Surrounding Population of an Assumed Release of Fission Products into the Atmosphere from a 300-Megawatt Nuclear Reactor Located at Lagoona Beach, Mich." by a study group at the University of Mich. (Released in July, 1957.)

For the purposes of these studies, accidents are postulated whose occurrence is almost impossible. A very severe accident can be imagined in which as much as 1% of the fission products escape from both the reactor vessel and the gastight enclosure of the building. Under the most favorable weather conditions no one other than plant personnel would be affected. The same accident, under very unfavorable conditions, would lead to lethal radiation doses to about 435 people. The probability of the latter case is very low. When weather condition frequency is taken into account, the "most probable" number receiving a lethal dose becomes zero and the average number is 20.

tion of a product in a machine from the desired thickness, weight, strength, moisture content, hardness, or profile. A warning is flashed to electronic gadgets, which then automatically adjust the machine's controls to correct the deviation.

Tracers

Tracerlab, Inc., now has a device that will enable a manufacturer to add short-lived radioisotopes to products during stages of manufacture, with the isotopes actually becoming part of the materials being made. Radiation from the isotopes thus will be able to control parts of the manufacturing process by automatically triggering sensitive controls.

Dr. Libby says process control applications of this type will be the "next big step in the application of radioisotopes. The possibilities here are enormous. To my mind the possible savings in the refining of petroleum alone should surpass those made when the refining was changed from a batch to a continuous process, controlled by instrumentation."

The U.S. Army Corps of Engineers is working with Nuclear-Chicago Corp. on a new soil density gage, which uses radioisotopes. It is expected to speed highway building by quickly determining the density of soil on a road bed that has been rolled by heavy construction machines.

Irradiation

Sinclair has used radiation to produce heat-resisting waxes that withstand temperatures of 150 F for up to 16 hr, a heat level that would melt ordinary wax.

Standard Oil of Ind. reports that a small amount of radiation can remove odors from gasoline. The Denver & Rio Grande Western Railroad finds that irradiated coal dust makes a better fuel for locomotives. Reason: Irradiation breaks the dust down into such fine particles that nearly all the fuel is consumed during burning.

SAE National Meetings

1957

September 9-12
National Farm, Construction and Industrial Machinery Meeting and Production Forum

September 30-October 5
Aeronautic Meeting, Aircraft Production Forum, and Aircraft Engineering Display
Ambassador, Los Angeles, Calif.

November 4-6
Transportation Meeting
Hotel Statler, Cleveland, Ohio

November 5-6
Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 6-8
Fuels and Lubricants Meeting
Hotel Statler, Cleveland, Ohio

1958

January 13-17
Annual Meeting and Engineering Display, The Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

March 4-6
Passenger Car, Body and Materials Meeting
Sheraton-Cadillac Hotel, Detroit, Mich.

March 31-April 2
Production Meeting and Forum
The Drake, Chicago, Ill.

April 8-11
Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display
Hotel Commodore, N. Y., N. Y.

June 8-13
Summer Meeting
Chalfonte-Haddon Hall
Atlantic City, N. J.

August 11-14
West Coast Meeting
The Ambassador, Los Angeles, Calif.

September 8-11
Farm, Construction and Industrial Machinery, Production Forum, and Engineering Display, Milwaukee Auditorium, Milwaukee, Wis.

Briefs of SAE PAPERS

Presented below are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. Order from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ each to members, 60¢ each to nonmembers.

AIRCRAFT

Progress in Aerial Refueling, P. G. SCHLOEMER. Presented Apr., 1957 15 p. Progress in design of flying boom and probe drogue systems of refueling military aircraft; particular reference to problems of fuel pressure control, surge control, air speed-altitude compatibility, and interference effects between tanker and receiver aircraft; component developments and problems; enumeration of problems needing additional development efforts.

Performance and Operational Studies of Two Full-Scale Jet-Engine Thrust-Reverser Systems, R. C. KOHL, J. S. ALGRANTI. Presented Apr., 1957 9 p. Problems associated with installation and use of thrust reverser studied at NACA Lewis Laboratory, one in pylon mounted engine simulating that on jet bomber or transport and other in fighter type aircraft; hemisphere thrust reverser test arrangement; effects of reverse thrust on aircraft and engine are emphasized.

Slow Take Off and Landing Aeroplane, R. BANNACK. Presented Jan., (Canadian Section) 4 p. Approach of DeHavilland Aircraft of Canada to STOL aircraft; advantages of civil and military applications; development and export figures of "Beaver" and "Otter"; project of larger unit DHC-4, Caribou, having aerodynamic and structural features tested in two earlier designs; expected payload of 2½ tons and takeoff and landing run of about 500 ft; future trends.

Helivector—One Man Helicopter, D. DeLACKNER. Presented Feb., 1957 (Dayton Section) 3 p. Development of aerocycle by DeLackner Helicopters and factors determining original design; stand-on principle enabled concentration of all elements in compact package; prototype testing conducted by firm in cooperation with Army; goal is development of completely integrated unit, including new power plant in which crankcase becomes platform and rotor system and landing gear attachment are utilized. See also Engineering Index 1955 p 477.

FUELS

What Fuel Characteristics Mean to
Continued on page 103

PRODUCTION FORUM

MONDAY . . . procurement . . . program scheduling and control of changes . . . large structural components . . . manufacturing techniques—high temperature sheet materials . . . quality control as related to manufacturing . . . test equipment . . .

TUESDAY . . . control of manufacturing costs . . . metal removal—high temperature material . . . electronic data processes, production control as used by manufacturing . . . plant engineering . . . management training . . . ground support equipment . . .

WEDNESDAY . . . aerodynamic smoothness and its impact on production . . . numerical machines, operation and maintenance . . . introducing new manufacturing techniques and processes into production . . . metal bonding . . .

TECHNICAL SESSION

WEDNESDAY . . . digital methods . . . shock and vibration . . . systems analysis . . . nuclear power . . .

THURSDAY . . . ground support . . . structures . . . missile accessories . . . materials and processes . . . STOL/VTOL/convertiplane . . . transport aircraft—design and maintenance . . .

FRIDAY . . . aerodynamics . . . electrical system design . . . turbine propulsion . . . turbine propulsion accessories . . . aircraft systems . . . engineering supervision.

LUNCHEONS

MONDAY . . . "Around the World in One Day" . . . B. F. Coggan, vice-president and division manager, Convair Division, General Dynamics Corp. . . .

TUESDAY . . . "Industrial Preparedness—Fact or Fancy" . . . Lt. General C. S. Irvine, USAF, Deputy Chief of Staff, Materiel . . .

WEDNESDAY . . . "What of the (Aircraft) Future?" . . . Air Commodore F. Rodwell Banks, director, Bristol Aeroplane Co., Ltd. . . .

THURSDAY . . . "Looking Down the Road to the Future of Helicopter Transportation" . . . C. M. Belinn, president, Los Angeles Airways, Inc. . . .

DINNER-DANCE

SATURDAY . . .

SAE CEP
COOPERATIVE ENGINEERING PROGRAM NEWS

B-58 "Hustler" Hydraulic System ... Revealed at A-6 Meeting

B-58 "Hustler" hydraulic system problems and solutions were reported to SAE Committee A-6 on Aircraft Hydraulic and Pneumatic Equipment at its May meeting in Boston. The bomber's hydraulic system falls into the Type III (−65 to 400F) temperature range developed by the Committee.

Design specifications call for a closed hydraulic system with boot-strap pressurization to 60 psi. Four engine-driven, 3000-psi 30-gpm pumps supply the power for flight controls, utilities, and special subsystems. Oronite 8515 hydraulic fluid is held between 100 and 350 F by thermostatic controlled cooling, and the fluid is cleaned by a simple ten micron filter.

Solving Design Problems

A complete, full-scale laboratory mock-up of the system has cut problem solution time to a tenth in some cases during the year and a half it has been operating. This tool supplied many of the solutions for Hustler design problems, such as:

- Gas entrainment and foaming of fluid is cut by only using the reservoirs when the fluid flow rate is low. High flows, which would splash and foam in reservoirs, by-pass the reservoirs. Good port locations accelerate gas and fluid separation.

- 300 F temperature difference between airframe and hydraulic system requires small tubing to be offset. Large (5/8 OD and above) tubing needed expansion glands which permitted tube slippage without clutching or axial jumping.

- To ease maintenance and avoid breaking into the system, the arrangement of components purges gases to the reservoirs for single point bleed off.

- Fluid level in an inaccessibly located reservoir is detected by a magnetized metal ring on the loading piston. A magnetic pointer on the outside locates the ring.

Hydraulic Fluid

The use of Oronite 8515 fluid stimulated the following controls to avoid failures:

- Nitrogen is used to displace the fluid from original containers to prevent hydrolysis from the moisture in air.

- No other fluid is brought in contact with Oronite to prevent contamination. Early use of MIL-0-5606 red oil for inspecting components resulted in bulk gelling of Oronite.

- Cleaning and polishing agents are suspected of causing the gel found on filters. The gel originated from $CaCO_3$.

Service replacement of fluid will be on a performance rather than time basis due to cost of fluid and variations in service conditions. At present, viscosity breakdown and contamination seem to be critical. Viscosity discard level is set at 6.0 cs at 210 F, and new fluid weighs in at 8.4 cs. Reclamation of fluid is being studied.

Materials

Difficulty with neoprene W base stock O-rings has been minimized by

Missiles Handling and Maintenance Investigated

E-21's AIRCRAFT TOOLING PANEL proposed the enlargement of its scope to include missiles handling and maintenance at a recent Quonset Point meeting. Shown aboard the U.S.S. Wasp are (l. to r.): L. M. Shipley, B. A. Beaton, T. A. Lyle, H. Marcheschi, H. E. Spencer, Com. J. L. McMahon, H. T. Choquette, and David Kravitz.

designing integrated component part. The rod gland seals are the most critical. Since this material degrades with heat, a better substitute is sought. Single-turn teflon back-up rings are successful while single and double spiral ones have failed. Integral teflon back-up inserts in the jam nuts of swivel fittings solved the O-ring extrusion problem.

High-pressure steel tubing is nickel-plated by the Kanigen electroless process to a 0.0002 to 0.0003 thickness for corrosion resistance. Thicker platings would force special machine runs to make the fittings. Cadmium plate is not used because it isn't compatible with the fluid.

Not all light-weight aluminum alloys can stand the 350 F system temperature. 24S, Alcoa 2618, 61S, and 14S are good; 75S is poor. Tests on magnesium show good compatibility and high-temperature alloys are being evaluated for use.

The above was reported to Committee A-6 by P. S. Kleven who is connected with the Hydraulics Engineering Department at the Convair Division of General Dynamics Corp. in Ft. Worth, Texas.

D-C Solenoids Recommended For Today's Aircraft

D-C solenoids with silicon diodes are recommended for use in 400-cps a-c electrical systems of today's aircraft. Diodes used to rectify a-c current must, however, operate within the particular temperature limitation of their application. So states the Relays Subcommittee (A-2R) of the Aircraft Electrical Equipment Committee (A-2).

The following are listed as valid reasons why 400-cps a-c solenoids do not appear practical for the present, anyway.

- There is a heavy penalty in inrush current on a 400-cps a-c solenoids, with inrush as much as 20 times the sealed current.
- If mechanically overloaded so that the solenoid cannot seal, the coil will burn up on the above inrush current.
- Objectionable 800-cps hum and chatter is extremely difficult to eliminate, and can result in peening of magnet pole faces and resultant fretting corrosion on pole faces.
- A 400-cps solenoid would generally be about 20% heavier than an equivalent d-c solenoid with rectifiers.

The subcommittee will in the future work closely with A-2's System Subcommittee (A-2Y) to produce further recommendations on a-c and d-c solenoids.

Missiles Research Replaces Winterization Program

As a result of the U. S. Army Corps of Engineer's swing toward missile research, no new winterization research programs will be instigated by the Engineering Research and Development Laboratories. At a meeting held at Detroit Arsenal, the Winterization Subcommittee of the Construction and Industrial Machinery Technical Committee was assured that its current program which involves the testing of four prototype vehicles in Alaska will be completed. For the time being, responsibility for the winterization of construction and industrial equipment will fall on the men in charge of the item.

The Subcommittee has been informed that the ERDL would like to see its continued operation.

Causes Suggested for Plated Steel Failures

Embrittlement or the formation of a stress alloy at elevated temperatures may be causing failures which have occurred with cadmium-plated steels used in aircraft wheels, axles, and shock struts. Attempts to explain the cause of failure are being made by both the Aircraft Wheels, Brakes, and Axles (A-5) and the Aircraft Landing Gear Shock and Control Mechanisms (A-12) Committees. One report noted that such failures seem to be caused by the formation of a stress alloy at temperatures approaching, but not necessarily in, the steel's draw range. It would appear that intergranular penetration of molten cadmium into the steel occurs. This phenomenon is not necessarily restricted to high-heat-treated steels.

Simultaneous with or subsequent to the stress alloy formation, application of a load may cause failure. For example, when stress concentrations, such as splines, are present during formation of the stress alloy, failures may occur.

Comments received on cadmium-plated high-heat-treated steels with ultimate tensile strength of or above 220,000 psi indicate that failures occur at temperatures of about 600 F. In some cases, the failures were reported to result from cadmium plate (not hydrogen) embrittlement.

Detroit Arsenal Weathering Facilities Visited

Detroit Arsenal's weathering facilities were visited by the Winterization Subcommittee of the Construction and Industrial Machinery Technical Committee. Shown here are (l. to r.): P. W. Espenschade, Co-chairman W. W. Cornman, Chairman M. G. Mardoian, E. M. Plunkard, W. R. Koerting, R. J. Bernotas, Capt. E. W. Ehler, J. H. Hyler, Y. Miller, M. R. Nicholson, H. G. Haines.

New RP on Headlamp Aiming Devices Approved

A new Recommended Practice setting up laboratory test procedures and requirements for headlamp aiming devices for mechanically aimable sealed-beam headlamp units, has been approved by the SAE Technical Board. The prescribed tests are intended to determine whether the device under test is capable of accurately positioning the headlamp units from their aiming pads. It also tests whether the device can maintain its accuracy in service within specified tolerances.

Detail development of the Recommended Practice was handled by a subcommittee appointed by the Lighting Committee. The membership of this subcommittee follows: Chairman A. L. Johnson, William Hood Dunwoody Institute; A. R. Chick, Electrical Testing Laboratories; Roy Deming, Kent-Moore; P. F. Dirksen, Weaver Manufacturing; Lawrence Easterday, John Bean Division; James Hennessy, Trulite Corp.; E. L. Hopkins, Hopkins Tool Co.; C. W. MacMillen, Bear Mfg. Co.;

G. E. Meese, General Electric; G. W. Onksen, Guide Lamp Div. of GM; D. Hoffman, Radiator Specialty Co., and H. C. Doane, General Motors.

Copies of the new Recommended Practice may be obtained from SAE Headquarters, 485 Lexington Ave., New York 17, N. Y.

15 New, 4 Revised Aero Reports Released

SEVEN new Aeronautical Recommended Practices, two new Aeronautical Standards, six new Aeronautical Materials Specifications, three revised ARPs, and one revised Aeronautical Information Report are now available. The ARPs and ASs may be obtained as a set (including index) or individually. The AMSs and AIR are currently available individually.

New Reports

- ARP 483—Anti-Skid Equipment
- ARP 488—Exits and Their Operation —Air Transport Cabin Emergency
- ARP 495—Escape Devices
- ARP 496 — Emergency Flotation Equipment
- ARP 498—Panels, Plastic Lighting, Design Criteria and Recommendations for Dimensioning and Tolerances
- ARP 560—Missile Hydraulic Pumps
- ARP 572—Elbow Assembly—Shielded Spark Plug—.750-20 Thread
- AS 474 — Flange-Accessory-Slotted Mounting Holes
- AS 482—Terminal-Lug, Crimp Style, Flag Type, for Copper Aircraft Cable
- AMS 2476—Electrolytic Treatment for Magnesium Base Alloys Alkaline Type (Full Coat)
- AMS 2478—Electrolytic Treatment for Magnesium Base Alloys Acid Type (Full Coat)
- AMS 4384—Magnesium Alloy Sheet, HK31A-O
- AMS 4385—Magnesium Alloy Sheet, HK31A-H24
- AMS 5353—Steel Castings, Precision Investment, Corrosion Resistant
- AMS 7455—Bolts and Screws, Steel, Low Alloy Heat Resistant—Hardened and Tempered—Roll Threaded

Revised Reports

- ARP 269A—Identification of Material for AN, MS, and AS Engine and Propeller Standard Utility Parts and also for Company Parts
- ARP 454A—Connection—Swivel, Piloted O-Ring (3 Bolt)
- ARP 455A—Connection—Swivel, Piloted O-Ring (4 & 6 Bolt)
- AIR No. 45A—Pumps, Hydraulic, Power Driven, Variable Delivery, Composite Outline Drawings

Technical Committee Profiles

IN April 1941, three men attended the first meeting of what was to become SAE Committee A-6 on Aircraft Hydraulic and Pneumatic Equipment. In May 1957, **Chairman B. R. Teree** opened the 42nd committee meeting where 278 members of the aviation industry and the services were in attendance. Engineers from 136 different companies and 8 government agencies participated.

An open, industry-wide, forum on technical problems related to research, development, and production of hydraulic and pneumatic systems and equipment is encouraged at A-6 meetings. A highlight of the May meeting involved a discussion of the B-58 Hustler as it is related to Type III (−65 to 400 F) hydraulic systems. Heat dissipation, seals, tubing, pump design, fittings, hydraulic fluid, and maintenance were discussed. (Details may be found on page 87.)

Industry and the services look to A-6 for technical guidance. A few recently completed examples are:

- A new ARP on missile hydraulic pumps.
- New specifications for variable delivery pumps, a 15 micron absolute filter, and pneumatic filters.
- A definition of the Type III temperature range for testing of hydraulic systems. Previously, Type II (−65 to 275 F) and Type I (−65 to 160 F) temperature ranges were established.
- Incorporation of Type II test requirements into existing military specifications.
- Revision of specifications on packing installations, teflon backup rings, pneumatic pressure switches, and pneumatic cylinders.

Current A-6 projects include revision of installation and test requirements for pneumatic systems. A joint U. S.-Canadian Aircraft industry investigation of flareless versus flared fittings is being conducted.


Teree


Super

Chairman Teree has been a permanent member of A-6 since 1943. He is vice-president in charge of engineering and manufacturing at Greer Hydraulics, Inc. An Associate Fellow of the Institute of Aeronautical Sciences and of the Royal Aeronautical Society, he serves as a member of the Executive Board and is chairman of the Aircraft Section of the National Conference on Industrial Hydraulics. Mr. Teree is also a member of ASME.

THE emphasis now placed on brake safety and the need for standard methods for evaluating vehicle brake design has increased activity in the Brake Committee's eight subcommittees, reports **Chairman R. K. Super.**

A revision of the SAE recommended practice on braking terminology under final consideration by the Brake Committee results from national and local braking studies in which committee members have participated.

Other subcommittees are making progress on unification of test codes for evaluating vehicle brake performance in all weight categories. This includes passenger cars. Test codes are also being unified for evaluating such items as brake linings and lining bonding cements.

Mr. Super, who is chief engineer at the Timken-Detroit Brake Division of Rockwell Spring & Axle Co., has been a member of the Brake Committee since its formation in 1947.

Tech Board OKs First Joint Drawing Standard

THE first SAE Aeronautical-Automotive Drawing Standard has been approved by the Technical Board. Pertaining to checking practices, the standard serves as a guide for the review of engineering drawings for functional fitness, dimensional accuracy, completeness, and clarity of presentation. It is the first tangible product of the Joint Aeronautical-Automotive Drawing Standards Committee which was established last year by the Technical Board to develop a joint drawing standards manual.

The checking practices project was developed under the leadership of W. B. Billingham and R. P. Trowbridge, the former reflecting aeronautical, and the latter, automotive interests.

P. G. Belitsos, chairman of the Joint Committee, anticipates that an entire series of joint standards dealing with basic drawing practices will be completed before the end of 1957. Other sections of the proposed joint drawing standards manual are expected to be completed early in 1958.

ASA Decimal Dimensioning Receives SAE Recognition

A new SAE Standard on decimal dimensioning scales for drafting purposes has been approved by the Technical Board. This Standard gives Society recognition to an existing American Standards Association document on inch-decimal dimensioning scales already widely used in the drafting rooms of industry.

The new Standard will assist supplier-user relations, particularly in the fields of pattern making and foundry operations.

Prior to Technical Board approval, this Standard was approved by the Automotive Drafting Standards Committee where it originated. It was also circulated for the approval of the Aeronautical Drafting Manual Committee (S-1) and the Joint Aeronautical-Automotive Drawing Standards Committee. It will appear in the 1958–1959 SAE Handbook.

Integrated Instrument Display Groupings Examined

LACK of uniformity of integrated instrument displays prompted SAE Aircraft Committees on Cockpit Standardization (S-7) and Aircraft Instruments (A-4) to form a joint Subcommittee (A-4/S-7) on Integrated Flight Displays. The new group will try to establish optimum display groupings from the standpoint of operational effectiveness. A guide for integrated instrument systems manufacturers may result from subcommittee recommendations.

Integrated instrument display and the logic inherent in the grouping of flight path intelligence signals were discussed by engineers from Lear, Sperry, Collins Radio, and Eclipse-Pioneer at the subcommittee's first meeting held August 28 and 29 in Chicago. Working groups were established to prepare pilot questionnaires.

Subcommittee Chairman J. R. Utterstom of Boeing Airplane Co. recently stated, "The task assigned this subcommittee is difficult since the issues are subjective and involve economics and established habit patterns. It is our sincere hope that an orderly integrated instrument display grouping will become apparent under sufficient impartial study."

Vapor Formation in Turbine Aircraft Studied

A mockup fuel system containing typical components used in high-performance gas-turbine aircraft forms the framework for observations on vapor formation during fuel-pump operation, and evaporation and liquid entrainment losses from fuel tanks. Results of the study are recorded in CRC 299, "Altitude Performance of Gas Turbine Fuels of Varying Volatility."

Test conditions were chosen to accentuate differences among currently used fuels. Included in the study were fuels ranging from the JP-1 type to the more volatile JP-3 type, aviation gasoline, fuel temperatures from 60 to 110 F, rates of climb to 10,000 fpm, terminal altitudes to 60,000 ft, and several different designs of engine and booster pumps.

One outstanding result of the test involving JP-3 type fuels was the large quantity of foam which formed during rapid climbing. With such fuels, entrainment of the liquid in the tank vent in some cases exceeded the evaporation tosses several times. Thus at 110 F, with JP-3 fuel, the total vent losses reached as high as ⅔ to ¾ of the fuel, which was even worse than the fuel losses suffered with aviation gasoline. These entrainment losses were affected by vapor space in tank, by rate of climb, and by tank pressurization. They appear to bear no simple relation to fuel properties.

Evaporation losses, exclusive of the foam, were in reasonable agreement with CRC formulas previously developed for aviation gasoline.

Performance of both engine pump and fuel tank booster pump was influenced by fuel volatility in accordance with past experience, though the higher rates of climb and higher altitudes aggravated the pumping difficulties. Tank pressurization is highly effective in alleviating pumping difficulties, if it can be permitted.

Choice of engine pump or booster pump did not materially alter the performance of volatile fuels.

There were no vent losses with JP-1 fuel and the performance of the mockup fuel system was not limited in tests up to 60,000 ft altitude, using this fuel.

CRC report 299 contains 59 pages, including graphs, tables, and diagrams. It is available from SAE Special Publications Department. Price $2 to members; $4 to nonmembers.

Accessory Vibration Studied by New Panel

VIBRATION related to engine and airframe mounted accessories is being studied by the new Vibration Panel of the Joint Aircraft Engine and Accessory Installations Committee (AE-1). Attention is focused on turbine and turboprop engines and their respective airframes. Reciprocating engines and engine components will not be included in the investigation.

Formation of two subpanels occurred at the Panel's first meeting called last May by Chariman L. B. Venable of General Electric Co. One of the subpanels is drafting procedures for specifying the limits of airframe mounted equipment. Its chairman, A. J. Kamm of Boeing Airplane Co., is seeking to compile data and plot an envelope of amplitude versus frequency superimposing on the envelope a family of curves of constant *g* values. In addition, this subpanel will plot a family of temperature curves required for airframe operation. A block graph of sinusoidal input versus temperatures and a block graph of acceleration spectral power density versus temperatures are also being developed.

The other subpanel will compile data on plotting vibration envelopes of engine and airframe mounted equipment by asking industry to plot all known

data (buckshot) on blank graphs provided by the subpanel, stating known conditions if possible. The graphs will cover turbine and turboprop engines and their respective airframes. H. P. Koehler of Orenda Engines Ltd. is chairman of this subpanel.

Reports on the above will be presented at the Vibration Panel's next meeting to be held this month.

Tabular System Expanded For Elastomer Compounds

TO improve flexibility and facilitate use of SAE 10R tables, one basic table is being prepared which consolidates all existing tables on elastomeric compounds. This is being effected by the SAE-ASTM Technical Committee on Automotive Rubber. Subsection Chairman T. M. Loring of Chicago Rawhide Mfg. Co. expects to ready this table for presentation to the International Standards organization slated to meet in the U. S. during the fall of 1959.

Under the new system, test methods and minimum values for SAE 10R will be expanded to include *all* application requirements (suffix letters). The suffix table will list permissible changes in durometer, tensile, elongation, and volume swell under various conditions of aging. Specific compression set values and load-deformation values will be incorporated. The suffix table is broken down into subclasses which indicate different levels of test severity.

The need for an expanded table is reflected by the recent Air Force and Navy rejection of MIL R 3065-B. Subsequent to this, a directive from the Secretary of Defense was issued to the Ordnance Department which stated that universal acceptance of MIL R 3065-B must be secured from all branches of the armed forces. This specification was originally prepared by the Ordnance Department in cooperation with SAE-ASTM with the object of tying it in with SAE 10R. Had the expanded table been ready, it is assumed that it would have been acceptable not only to Ordnance, but also to the Air Force and Navy.

Ozone Box Testing Proves Feasible

OZONE box testing now appears feasible since comparable test results were reported recently by five companies to the SAE-ASTM Technical Committee on Automotive Rubber. The main advantges of box testing are: Test period is shorter than that required for out-of-doors testing; and variation in ozone concentration due to different localities is eliminated.

Two compounds containing different amounts of neoprene were used for the tests. One compound contained 35% by volume of neoprene, while the other contained 55%. Tests were run at 100 F, and the concentrations of ozone were 0.25, 0.50, and 0.75 parts per million. Test times were 24, 48, and 72 hr. Airflow was kept constant at 4.5–5.5 cu ft per min. The compound containing the higher proportion of neoprene showed somewhat less cracking tendencies than the other compound. Averaging rating by the five participating companies for 0.5 ppm of ozone was 1, 2, and 3 for 24, 48, and 72 hr, respectively.

Both the Bush and the Mast ozone test boxes were represented. Test pieces are now being photographed by du Pont, and more extensive round robin tests will now be made to include all interested companies.

CRC Recommends Technique For Rebuilding Test Axle

THE new CRC L-40 technique for rebuilding Chevrolet third-member assemblies for use with CRC L-19 gear lubricant axles is presented in CRC report 302. Although instructions in the report are self-explanatory, some differences in methods and tolerances between the L-40 technique and the Chevrolet shop manual do exist. CRC report 302, "Development of a Technique for Rebuilding CRC L-19 Gear Lubricant Test Axles," recommends adherence to the L-40 technique.

The report contains 15 pp. including an appendix, and is available from SAE Special Publication Department. Price: $1 to members; $2 to nonmembers.

News Briefs of SAE-ASTM Automotive Rubber Group

THE following news briefs result from a June 13–14 Detroit meeting of the SAE-ASTM Technical Committee on Automotive Rubber.

Fluid Aging Study to Include Neoprene Compounds—Neoprene compounds will be included in a study of the effect of aromatic fuels on rubber. Leonard Raymond of Socony Mobil Oil Co. and N. L. Catton of du Pont will recommend those gasolines which are and will be suitable for continued investigation. The program will be detailed at the September meeting.

Data on Tear Resistance Tests Accumulate—Data on tear resistance for various grades of compounds are being accumulated. An attempt is being made to find values for tensiles below 1000 psi, between 1000 and 2000 psi, and above 2000 psi.

Impact Tests Independent of Machine Shape and Dimensions Discussed—The possibilities of describing a standard test method independent of the shape and dimension of any particular machine were discussed. This will be pursued further at the September meeting.

Dipped Goods and Coatings—Data on neoprene compounds subjected to No. 2 oil are being obtained. Cold flexing tests are also being run.

Compression Set Testing—A request is being considered which pertains to shortening the present 70-hr compression set test period to 22 hr.

Technishorts . . .

A NEW RECOMMENDED PRACTICE ON AIR BRAKE BUILD-UP TIME INSTRUMENTATION has been approved by the Technical Board. It describes the instrumentation necessary for measuring build-up time of air pressure at the brake chamber. Developed by the Brake System Test Subcommittee of the Transportation and Maintenance Technical Committee, this report will be used by the Brake Test Fitting Location Subcommittee for its investigating of locations for installation of the air brake build-up time instrument. The Brake Test Fitting Location Subcommittee's scope was recently broadened to include the establishment of a test procedure for fleet use in the field.

THE NEW AVIATION PETROLEUM PRODUCTS SUBCOMMITTEE will act as a liaison between the Fuels and Lubricants Technical Committee and the Aeronautical Materials Specification Division—pending the latter's request for assistance on problems dealing with petroleum products. T. B. Rendel of Shell Oil Co. is chairman of the new group recently created by the Fuels and Lubricants Technical Committee.

THE HARDENABILITY-BAND METHOD OF SPECIFYING CARBON STEELS, similar to that used for the past 10 years for alloy steels, will be worked on by a newly appointed SAE Task Group. Created by the SAE Iron and Steel Technical Committee's Executive Committee, the group will work with a similar AISI committee.

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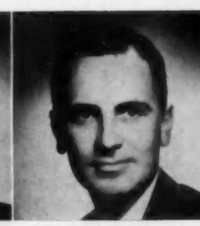


Casey

Zeigler

Lincoln

CLARENCE G. WOOD has been appointed executive director of the Cleveland Senior Council, an organization of retired executives.

For the past five years, Wood has been chief of procurement and technical assistant in the Federal Small Business Administration. During his career, Wood has served as director of sales and advertising for the American Coach and Body Co. and also as operator of wholesale automotive parts establishments.

Wood has been a member of SAE since 1917.

WILLIAM H. HERBERT has retired from the Bell Telephone Co. of Canada as superintendent of vehicles for the Eastern region. He had been with the company for 44 years.

Herbert has been a member of SAE for 30 years.

JULES C. LAEGELER has been made chief engineer of the Frank G. Hough Co., Libertyville, Ill. Formerly he was manager of the product improvement department for the company.

Laegeler joined the organization in 1951 as an experimental engineer, and subsequently was named departmental manager in 1956.

HARRY S. GERSTUNG is now associated with the Alpha Molykote Corp., Stamford, Conn., as manager of technical service. Formerly Gerstung was chief automotive engineer for Sinclair Refining Co., N. Y.

Gerstung has been a member of SAE since 1941 and served as 1956–57 vice-chairman, Fuels and Lubricants, Metropolitan Section.

RICHARD M. HOWLETT, formerly technical service engineer, Paramins Division, Enjay Co., Inc., has moved to the Market Development Division as senior market development engineer.

Howlett was employed by an Enjay research affiliate before he came to Enjay as a technical representative.

BRIAN CASEY has been appointed assistant manager of the Paramins Division, Enjay Co. Formerly he was technical representative of the division. Casey was a research chemist with the Sun Oil Co. before joining Enjay in 1954.

PHILIP ZEIGLER has been made chief engineer of Saginaw Steering Gear Division, General Motors Corp. In 1941 he became affiliated with Saginaw Steering Gear, and in 1943 was made methods engineer. In 1952 he was named assistant chief engineer in charge of hydraulic steering mechanisms.

Zeigler is vice-chairman of the Mid-Michigan Section of the SAE.

C. W. LINCOLN has been appointed technical assistant to the general manager of the Saginaw Steering Gear Division, GMC.

Lincoln joined Saginaw Steering Gear in 1932 as a tool designer and was appointed chief engineer of the division in 1948.

He is a past vice-chairman of SAE Mid-Michigan Section.

EDMUND T. PRICE has accepted a professorship of human relations at California Western University, San Diego, Calif., and is retiring as Solar Aircraft Co.'s chairman of the board of directors. He will continue to serve as a director of Solar, and as a consultant to the company.

Price joined Solar's predecessor company, the Prudden Aircraft Corp., in 1928. In 1929 he founded the Solar Aircraft Co. and became president and general manager in 1930, positions he retained until becoming board chairman in 1956.

J. E. HACKER has been made manager—Crawler Tractors, Euclid Division, General Motors Corp. Formerly he was plant manager at the Clinton Road Plant, Cleveland, Ohio.

J. H. CARMICHAEL has been elected chairman of Capital Airlines, Inc. Until the recent appointment, Carmichael has been president and chief executive officer of Capital Airlines.

WILLIAM M. SCHMIDT has been named executive stylist of Chrysler Corp. Formerly Schmidt was vice-president and director of styling for Studebaker-Packard Corp.

WILLARD F. ROCKWELL has been appointed to the National Defense Committee of the U.S. Chamber of Commerce for a term of one year.

Rockwell is also board chairman of Rockwell Mfg. Co. and Rockwell Spring and Axle Co. He is a former Assistant Secretary of Defense and current national chairman of the Association of the U. S. Army.

RICHARD R. BOOTH, formerly engine price analyst at Cummins Engine Co., Inc., Columbus, Ind., has been made president of BO-CO-MO-Enterprises, Inc., Delray Beach, Fla.

GABRIEL M. GIANNINI, president of G. M. Giannini & Co., Inc., Pasadena, Calif., has also beeen made director of Giannini Research Laboratory, Santa Ana, Calif.


Exner


Drader


Sleigh


Walther


Macauley


Miller


Finch


Chayne

VIRGIL M. EXNER has been elected vice-president of Chrysler Corp., a position he will hold in addition to continuing as director of styling, Engineering Division, for the company.

JOSEPH C. DRADER has retired as vice-president of the Michigan Tool Co., Detroit. Drader has been with the company for more than 40 years and recently has been heading the company's research work in the gear development field. Drader started as a lathe hand in 1916 and subsequently was appointed general manager in 1939 and elected vice-president of the company in 1941.

EDWARD BARRY SLEIGH has been made technical assistant to the lubricants manager, at the Shell Oil Co. of Canada, Ltd., Toronto, Ont. Formerly he was division marketing service manager at the Shell Oil Co.

In 1957, Sleigh served as British Columbia Section SAE vice-chairman.

DANIEL A. WALTHER has been made chief engineer at the Dayton Steel Foundry of Dayton, Ohio. Formerly he was assistant to the chief engineer at Dayton Steel Foundry.

Walther joined the company in 1942 and has held positions in the tool, maintenance, and electrical divisions. He is also president of Moraine Mfg. Co., a subsidiary of Dayton Steel Foundry.

JACK B. MACAULEY, JR. has been appointed Deputy Assistant Secretary of Defense for Research and Engineering at the Pentagon in Washington, D. C. He has retired as director, technical coordination, Ethyl Corp.

Macauley has formerly served in Washington in Research and Development, and also with the consolidation of the offices of Assistant Secretary of Defense for Engineering and the Assistant Secretary of Defense for Research and Development.

ARTHUR E. MILLER has been made director of research at the Scott Aviation Corp., Lancaster, N. Y. Formerly he was chief engineer, responsible for the design and development of aviation oxygen equipment and respiratory protective equipment, for the company.

KENNETH W. FINCH has been made chief engineer of the Weatherhead Co.'s Fort Wayne Division, Fort Wayne, Ind. Formerly he was chief engineer of the Automotive Division of Fedders-Quigan Corp.

Finch started his engineering career in 1940 as apprentice methods engineer at the Ternstedt Division of General Motors Corp. He joined Fedders-Quigan in 1940 as design engineer and was made chief engineer in 1955.

CHARLES A. CHAYNE, vice-president in charge of engineering, General Motors Corp., has been elected to a five-year term on the Massachusetts Institute of Technology governing body.

A graduate and former instructor at M.I.T., Chayne was elected one of three Alumni Association representatives on the M.I.T. Corporation. He has been a member of M.I.T.'s Mechanical Engineering Visiting Committee since 1951. Chayne graduated from the institution in 1919, joined the faculty a year later, and was an instructor in mechanical engineering until 1926.

HORACE W. THUE is now affiliated with the International Business Machines Corp. Formerly he was works manager at the Santa Monica Division of Douglas Aircraft Co., Inc., a position he held since 1950.

Thue joined Douglas in 1940 and served in estimating and production analysis before becoming production manager of the Santa Monica Division in 1948.

HARRY LEON STRYKER has been made assistant engineer, field engineering force, at the Western Electric Co., Winston-Salem, N. C. Formerly he was an instructor, guided missiles, with the U. S. Air Force at Lowry AFB, Denver, Colo.

MILFORD EUGENE PRATHER has been made assistant chief, tractor unit, combat vehicle section, Research and Development Division, at the Detroit Arsenal, Ordnance Tank-Automotive Command, U. S. Army, Center Line, Mich. Formerly he was chief, Northland (Arctic) vehicle section, combat vehicle branch, Research and Development Division, U. S. Army.

COL. ALBERT A. ARNHYM has been made special assistant to the Commander in Chief, Strategic Air Command, at Offutt Air Force Base, Nebr. Formerly he was director of information service of the Air Research and Development Command, U. S. Air Force, Baltimore, Md.

Arnhym began his military career in 1936 and, during World War II, worked with captured technical information for Army Air Force Intelligence. After the war he was assigned to Headquarters, Air Materiel Command, at Wright Field, Ohio, where he organized and directed the Central Air Documents Office, now known as the Armed Services Technical Information Agency.

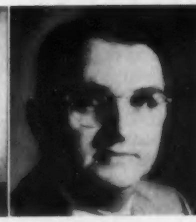
GEORGE P. SMITH has become affiliated with the Great Lakes Screw Corp. in Chicago. Formerly he was an engineer, technical service, Ethyl Corp., Research and Engineering, Detroit.

SETH H. STONER has been made general manager of the New Departure Division of General Motors Corp., which operates plants in Bristol and Meriden, Conn., and Sandusky, Ohio. Formerly he was chief engineer of the New Departure Division.

PAUL W. RHAME, a veteran of 34 years with General Motors Corp., has retired as general manager of New Departure Division. He started his career at GMC with the AC Spark Plug Division and subsequently was made manufacturing manager of the division. In 1952 Rhame was made general manager of the Rochester Products Division of GMC, and later became assistant general manager of the Allison Division.


Wheaton


Ellis


Leingang


Wyle


Hawkins


Richie


Wells


Pickup

FLOYD L. WHEATON has been made vice-president for Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio. He will administer general marketing policies, long-range sales objectives, market research, and advertising of all company products in domestic and foreign markets. Formerly he was sales manager at the Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio.

ROLLO G. ELLIS has been made staff assistant to the vice-president and assistant general manager of Micromatic Hone Corp., Detroit.

Ellis joined the corporation in 1939 and was made chief engineer in 1955.

WILLIAM C. LEINGANG has been made general manager of Stokes Molded Products Division of the Electric Storage Battery Co., Trenton, N. J. Leingang formerly was an assistant to the president of the Stokes Division.

FRANK S. WYLE is now president of Wyle Associates, a newly formed national organization of sales and service engineering specialists in missile/aircraft testing which will represent independent testing laboratories and test equipment manufacturers. Formerly he was president of Wyle Laboratories, an affiliate of Wyle Associates.

ROBERT B. HAWKINS has been appointed general sales manager, Zollner Corp. He will manage the newly-established sales office in Detroit. Previously, Hawkins was regional manager of Sterling Aluminum Products, Inc.

ROBERT RITCHIE has been made assistant to the general sales manager of the Zollner Corp. Formerly he was sales engineeer at Sterling Aluminum Products, Inc.

WILBUR J. WELLS has been made district sales manager for the Western sales zone, Champion Spark Plug Co. With Champion since 1921, he has served as territory representative of both the Seattle and Los Angeles areas.

JUDSON H. PICKUP has been made territory representative of the Los Angeles area for Champion Spark Plug Co. With Champion since 1940, he has been territory representative of the San Francisco area since 1956.

WILLIAM STEPHAN FLOGAUS is now a service engineer at the Sundstrand Aviation Service Corp., Rockford, Ill. Formerly he was chief design engineer at the Sundstrand Division in Denver, Colo.

FRANK W. BALL, JR. has been made design analysis engineer at the Oldsmobile Division, General Motors Corp., Lansing, Mich. Ball formerly was a laboratories engineer at Oldsmobile Division.

JAMES H. GRAAS, formerly sales engineer at the N.Y. Air Brake Co., Kalamazoo, Mich., is now assistant manager, mobile application department at Dynex, Inc. of Pewaukee, Wis.

EDWARD T. GIBLIN, formerly territory manager in the New England area, has been appointed New England States district manager for the Walker Marketing Corp., of Racine, Wis. Giblin has been with the company since 1948.

ALTON B. CRAMPTON has been made the administrative head of a new technical unit of the Esso Research and Engineering Co., Linden, N. J. The new technical unit, with headquarters in London, will assist European affiliates.

Crampton joined Esso's Products Research Division in 1938 and, prior to his new post, had served with the marketing coordination department of Standard Oil Co. (N. J.) on a rotational assignment.

An active member of SAE since 1947, Crampton has served on numerous SAE committees.

STUART G. BAITS is retiring after more than 42 years with American Motors Corp. and its predecessor, Hudson Motor Car Co., Detroit.

Baits joined Hudson in 1915, and served as chief engineer, a director of the company, and in 1934 he became assistant general manager. In 1936 Baits was elected first vice-president of Hudson, a position he held at the time Hudson and Nash-Kelvinator merged. He will continue to serve the company in a consulting capacity.

MICHAEL FERENCE, JR., recently appointed director of Ford Motor Co.'s scientific laboratory, is one of 10 members of the national Earth Satellite Technical Panel. He is the only panel member from the Detroit area.

ROBERT J. TAYLOR has been made senior product engineer on tire construction in the Vredestein Tire Co., Enschede, The Netherlands. Formerly he was product engineer at the B. F. Goodrich Co., Akron, Ohio.

ROBERT E. ARONSTEIN, previously associate engineer at the Atomic Power Division, Westinghouse Electric Corp., Pittsburgh, Pa., has been made engineer-research at the Atomics International Division of North American Aviation, Inc., Canoga Park, Calif. Aronstein is now working with nuclear engineering analysis and coordination on advanced reactor systems.

R. F. TOMKINSON, formerly account executive at the Detroit office, Good Year Tire and Rubber Co., Akron, Ohio, has been named manager of the manufacturers sales department in Akron.

THOMAS J. HARRIS has been made director of marketing for the Aero Design & Engineering Co., Bethany, Okla. Formerly Harris was director of freight sales for American Airlines, Inc., having served in this capacity since 1955.

RICHARD C. NELSON has been made assistant chief engineer at the Outboard Marine Corp., Waukegan, Ill. Nelson formerly was project engineer at Johnson Motors Division, Outboard Marine Corp.

WALTER G. PATTON has joined the SAE staff in the meetings and information development areas. He will operate out of the Society's Detroit office in the New Center Building.

Patton

Patton will be staff representative for five Activity Committees . . . Passenger Car, Truck and Bus, Body, Production, and Engineering Materials. In addition to functioning with these Activities in development of programs for technical sessions at national meetings, he will also work with these groups in channeling technical information developed by them directly to the publications of the Society. For that reason he will also carry responsibilities as an Engineering Editor of SAE Journal.

Patton comes to SAE from "Iron Age," for which he was Detroit Editor and wrote the column "Assembly Line," and was later Engineering Editor. Prior to his 11-year stint at "Iron Age," Patton was associated with Climax Molybdenum, in its technical publications operations. He has also been with General Motors and Detroit Edison.

While with Climax Molybdenum, he served as secretary of the National Emergency Alloy Steel Committee. He was also Chairman of the Detroit Chapter of the American Society for Metals in 1946–47.

He was graduated from the University of Michigan, where he devoted much of his undergraduate studies to courses in the Engineering College.

NIKOLAUS VON RUCKER, technical director, Porsche automobile factory, Dr. Ing. h.c.F. Porsche K. G., appears in front of a Porsche car bearing the license "S-AE." The "S" represents Stuttgart where the car is registered.

von Rucker served as manager, development departments, before becoming technical director.

LOUIS FRANCIS MOCK, JR., formerly sales manager of Gulf Oil Corp., Houston, Tex., has been made general manager of Bowman Equipment Co., Inc.

Mock has served actively with the SAE Texas Gulf Coast Section and recently retired as 1956–57 Section chairman.

ERIC C. NULSEN, formerly with the U. S. Navy at the Naval Base, Philadelphia, has been made project engineer, Shaw-Box Crane Division, Manning, Maxwell and Moore, Inc., Muskegon, Mich.

BOB BESTER has been named to the newly-created post of sales planning and merchandising manager of a new line of hydraulic hose assembly and couplings, Stewart-Warner Corp. Bester had been factory sales representative with Anchor Coupling Co., Inc., before he joined Stewart-Warner.

JAMES B. KENDRICK has been appointed chief of preliminary design in the technical staff, Guided Missile Research Division, Aeronautical Research and Development Laboratory, Ramo-Wooldridge Corp., Los Angeles.

Prior to his new post, Kendrick had served as chief of preliminary design and special projects, Aerophysics Development Corp.

H. L. ATWOOD has joined the First National Co. of Nevada assisting the president in the capacity of consulting engineer.

RUSSELL WADE SENIFF, manager of research for the Baltimore & Ohio Railroad, has been elected for three-year term as vice-president of the American Society for Testing Materials, Philadelphia, Pa.

FRANCIS L. LaQUE, vice-president and manager of the Development and Research Division, International Nickel Co., has been elected vice-president of the American Society for Testing Materials, Philadelphia, Pa., for a two-year term.

LEONARD W. LEWANDOWSKI has been made manager of Assembly and Warehousing Operations at the Flexonics Corp., Santa Ana, Calif. Lewandowski formerly was California Plant manager at the Flex-O-Tube Division, Meridan Corp., North Hollywood, Calif.

GUISEPPE GABRIELLI, director, Divisione Aviazione, FIAT, has been named Italian representative to the Provisional Council of the International Council of Aeronautical Sciences.

The ICAS is a newly formed, worldwide organization dedicated to extend collaboration in all scientific areas pertaining to mechanical flight. Every nation with an organized society of aeronautical sciences will be invited to participate.

HARRY LUTHER KEELER, JR., has been made experimental engineer of General Motors Corp.'s Chevrolet Division at Milford, Mich. Formerly he was assistant experimental engineer, American Motors Corp., Detroit, Mich.

JAMES C. ANTON, formerly service engineer, Bendix Aviation Corp., has been made field service engineer of the Chandler-Evans Division, Pratt & Whitney Co., Inc., West Hartford, Conn.

RAYMOND L. JOHNSON, formerly chemical engineer at the Petroleum Laboratory, E. I. duPont de Nemours & Co., Inc., Wilmington, Del., is now a chemist at Sperry Gyroscope Co. in Great Neck, N. Y.

HOWARD G. KURTZ, JR., senior associate of Handy Associates, Inc., has recently had published a paper on "An Engineer vs. War." The article attempts to show that the engineering approach can be used to bring some of the problems leading to war into clearer focus.

The Institute for International Order has set up a special fund to finance distribution of reprints of the article.

H. SWAYNE GARRISON has been made project engineer at O. E. Szekely & Associates, Inc., Commerce, Ga. He formerly was senior design engineer at LeTourneau-Westinghouse Co., Peoria, Ill.

DAVID J. HLUBEK has been made junior designer at the Caterpillar Tractor Co., Joliet, Ill. Hlubek formerly was in the U. S. Army in Germany.

Continued on page 101

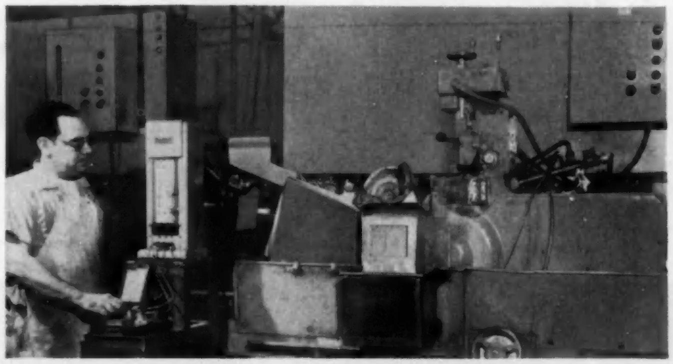
Obituaries

EDWARD V. CORDES . . . (M'47) . . . vice-president, Berman Service Inc., Allentown, Pa. . . . joined the company in 1950 was vice-president and general manager . . . died June 15 . . . born 1898 . . .

GEORGE RONALD DONALDSON . . . (A'41) . . . general manager, special accounts, Tire Division, B. F. Goodrich Canada, Ltd. . . . joined the Sales Division of the company in 1915 . . . died June 16 . . . born 1895 . . .

IVAN W. HANSEN . . . (A'56) . . . sales engineer, Hyatt Bearings Division, General Motors Corp. . . . joined GMC at Rochester Products Division in 1942, interrupted by military service and further education . . . died May 29 . . . born 1924 . . .

When you think of tapered roller bearings think of HYATT



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Nearly <u>half</u> of all American cars and trucks built today have HYATT Hy-Roll Tapered Bearings

For decades, the name HYATT has stood for highest quality in roller bearings. Today, it means *even higher* quality—because now HYATT craftsmen have the last word in electronic controls to help them produce tapered bearings with *greater uniformity than ever before achieved in quantity production.*

Today's HYATT Hy-Roll Tapered Bearings help assure smoother, more dependable performance than you could ever build into your tapered bearing applications before. If you want the *best*, you want HYATT Hy-Roll Tapered Bearings! Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT ***HY-ROLL BEARINGS*** **FOR CARS AND TRUCKS**

About SAE Members

Continued from page 98

HAROLD R. KEMMERER has been named manager, products application department, Shell Oil Co. Formerly Kemmerer was assistant manager of the company's manufacturing research department for seven years. He began his career with Shell in 1935 as junior mechanical engineer at the Wood River, Ill., refinery.

KARL L. HERRMANN has been issued a type certificate for his Model 375 engine from the Civil Aeronautics Administration. Herrmann is owner and manager of the Herrmann Engineering Co., Glendale, Calif.

PAUL S. McKIBBEN has been made chief engineer at the Oscar-Paul Corp., Los Angeles, Calif. Formerly he was chief engineer, Karl Douglas Division, Thompson Products, Inc., Hawthorne, Calif.

EUGENE MICHALCZYK has joined Western Auto Supply, Santa Paula, Calif. Previously he was lead mechanic, maintenance department, American Airlines Inc.

CHARLES R. RUTHERFORD has become patent attorney at the Administrative Engineering Center, Vickers, Inc., Division, Sperry Rand Corp. Formerly Rutherford was a patent engineer at Houdaille Industries, Highland Park, Mich.

Rutherford was graduated from the University of Detroit Law School in 1957 and recently became a member of the Michigan Bar.

LESTER MURRAY, formerly staff engineer, electrical equipment, Cadillac Motor Car Division, General Motors Corp., has been appointed staff engineer in charge of the electrical accessories, heating and air conditioning section, Cadillac Division.

Murray started with Cadillac in 1938 as a radio engineer. He became an assistant staff engineer in 1948 and in 1950 was transferred to the Cadillac-operated Cleveland Ordnance Plant as staff engineer in charge of electrical equipment.

STANLEY F. KING has been made project engineer at the Electric Auto-Lite Co., Toledo, Ohio. He was formerly a project engineer at the Power Equipment Co., in Detroit, Mich.

S. C. BHATTACHARYYA has been named chief instructor mechanical at the college of Military Engineering, Kirkee, Ponna, India. Formerly he was brigade electrical and mechanical engineer in the Indian Army, New Delhi, India.

Briefs of SAE PAPERS

Continued from page 85

Turbine Engine Airplane, C. A. WEISE. Presented Jan., 1957 (Southern California Section) 8 p. Limitations of specifications for turbine engine fuels are given, many of which relate to engine characteristics; limitations of interest to airframe designer; desirable specification for fuel that will give greatest overall profit for airlines; until such fuel is available, JP4 appears satisfactory compromise.

Discussion—Grades of Commercial Aviation Fuels, A. E. SMITH. Presented Jan., 1957 (Southern California Section) 6 p. With view to specifications being prepared by ASTM for proposed kerosene type jet fuel "Turbine Fuel A" and proposed wide-cut gasoline "Turbine Fuel B", commercial aspects are discussed that will have important bearing on price; how to achieve economical jet fuels for ariline consumption; kerosene "dual purpose" fuel; concentration on four or five grades of gasoline instead of present 11 fuels currently specified.

Problems That Can be Helped by Better Fuels and Lubes, C. R. WYNNE. Presented Jan., 1957 (Southern California Section) 4 p. Problems faced by owners and managers of large fleets of motor vehicles; task of maintenance department; requirements of fuels and lubricants enumerated for securing simplified maintenance service; author's experience with fuels and lubricants, as Police Transportation Superintendent, Los Angeles, operating over 1350 vehicles, including passenger cars, motor cycles, buses and trucks.

GROUND VEHICLES

Operating Experience with Automatic Transmission, G. H. MAXWELL. Presented June, 1957 10 p. Figures reported by several companies summarize experience made with twin hydramatic, and 4- and 8-speed automatic truck transmissions; comments and statement of companies and operators quoted and compared; need of cooperation between manufacturers, mechanics and drivers is pointed out.

New Automatic Laboratory at Detroit Arsenal, J. H. HENKEL, R. E. THIBODEAU, G. A. TUTTLE. Presented June, 1957 17 p. New test facility at Dynamometer Laboratory provides six engine cells, two transmission cells and vehicular test cell; equipment and capabilities; electronic type instrumentation permits rapid scanning and print of up to 400 test variables of temperature and pressure measurements; block diagram of digital recording and monitoring system; safety devices.

Determination of True Engine Friction, R. E. GISH, J. D. McCULLOUGH, J. B. RETZLOFF, H. T. MUELLER. Presented June, 1957 45 p. Comparison of motoring and firing friction and fundamental data on potential improvements in power and thermal efficiency that are obtainable by raising compression ratios; method employed by Ethyl Corp, Detroit, Mich, is explained, specially built test engine and test conditions described; instrumentation and results.

Engine Transient Performance or Why Inertia Wheel Testing, R. N. SHIELDS. Presented June, 1957 10 p. Inertia wheel which is basically specially constructed flywheel, provides new tool for measuring transient en-

Briefs of SAE PAPERS

gine performance, allowing engine to perform in laboratory in same manner as when powering vehicle; list of variables and components which can be tested on inertia wheel; method can be used to develop parts utilizing or dealing with heat, air or gasoline flow and being subject to time lag.

What's New in Air Filters, R. E. NORRIS. Presented Jan., 1957 (Northwest Sec) 4 p. Dry air filter, developed by Purolator Products, Inc, consists of paper element of special fiber stock, impregnated with phenolic resin providing controlled porosity and structural stability; performance of Chrysler 300 engine using standard filter and using dry air filter compared.

Heavy Duty Oil—Slow Run-in Question, A. M. BRENNEKE. Presented Jan., 1957 (Northern California Section) 16 p. Review of information and data presented in paper, May 1955, reprinted here as appendix; additional data given and mechanical factors of piston rings and other critical engine components as they affect question of run-in, discussed. See Engineering Index 1955 p 794.

Ins and Outs of Motor Truck Noise, W. A. BONVALLET. Presented Feb., 1957 (Detroit Section) 6 p. Control of noise by providing large mufflers of proper design on new vehicles; comparison of muffler volume/engine displacement ratios for 1953 and 1954 GMC trucks; development of measuring method; it is suggested that older trucks be equipped with adequate replacement mufflers to meet new vehicle standards.

Application of Diesel Engines to Marine Industry, F. S. DRISCOLL. Presented Mar., 1957 (New England Section) 8 p. Overall approach taken by General Motors' Detroit Diesel Engine Div is outlined and examples of complications encountered discussed; marine propulsion engines are manufactured in three basic series identified as 51, 71 and 110 for three general categories: work boat, pleasure craft, and crew boat; factors to be considered when installing engine and service requirements; development of 4- and 6-cyl series 71 equipped with turbochargers.

Improved Axle Life—Three-Way Responsibility, L. RAYMOND. Presented Mar., 1957, Los Angeles, Calif., 19 p. Hypoid axles are most heavily loaded and critical components of car or truck; responsibilities of builder for proper design, manufacture, installation and service; of lubricant supplier for continued improvement in gear lubricant quality and performance; and of user for operation and maintenance are covered; future trends.

Mobile Instrumentation for Testing of Earthmoving Equipment, W. D. SPEIGHT, W. H. JONES. Presented Mar., 1957, Peoria, Ill., 11 p. Development and present status of instrumentation at Caterpillar Tractor Co.; most highly developed mobile instrumentation equipment is "dynamic measurements" vehicle, built to embody all features found desirable in experience with previous units; transducers used with mobile instrument systems.

Aluminum in Earthmoving Equipment, W. C. WELTMAN. Presented Mar., 1957, Peoria, Ill., 2 p. Through judicious use of aluminum alloys in proved application, 10 to 15% increase in payload capacity can be achieved at no increase in gross vehicle weight; example of aluminum applications in over-the-road and in off-highway service and weight savings achieved.

MATERIALS

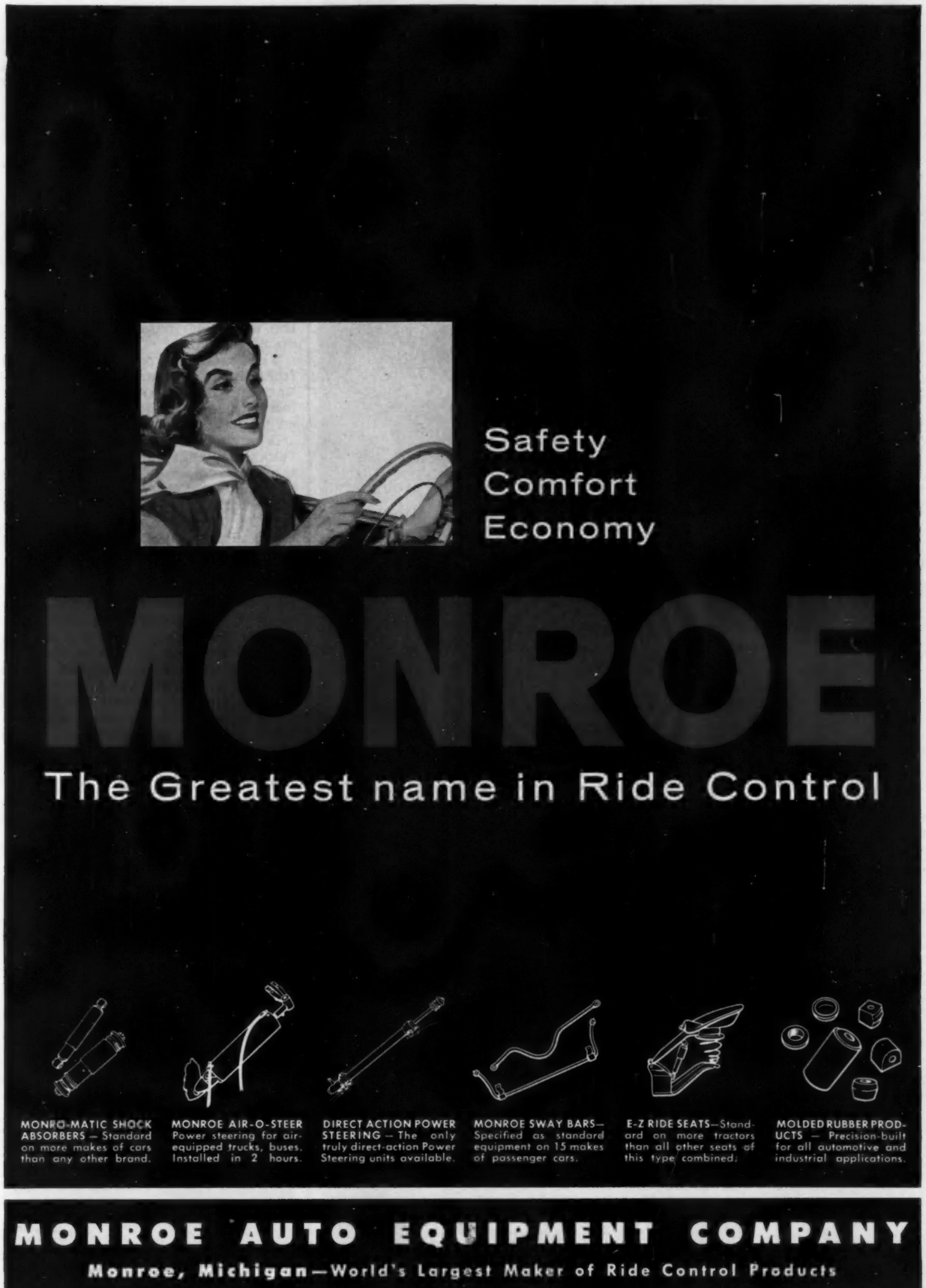
Beam Strength of Modern Gear Tooth Design, B. W. KELLEY, R. PEDERSEN. Presented Mar., 1957, Peoria, Ill., 16 p, (discussion) 7 p. Critical review of presently used formulas and methods for determining beam strength of gears; studies at Caterpillar Tractor Co. to obtain another stress correction formula for 25° pressure angle combining best features of Lewis and Heywood methods; description of photoelastic models used; comparison of various formulas and test results verify accuracy of approach.

PRODUCTION

New Machining Techniques Made Possible by Electro Machining, C. P. PORTERFIELD. Presented Mar., 1957, Buffalo, N. Y., 6 p. Electro machining is divided into four basic groups: sparkover initiated discharge machining, contact initiated discharge machining, electrolytically assisted grinding, and ultrasonic machining; sparkover initiated discharge machining, explained in detail is used for work in any conducting material; process is of particular value when applied to high temperature alloys or sintered carbides.

Application of Oxide Cutting Tools, E. KIBBITT. Presented Mar., 1957, Buffalo, N. Y., 6 p. Aluminum oxide presents new concept in cutting tools capable of machining nonferrous metals and steels; general advantages; economical performance is best obtained in higher speed ranges; tool plan geometry and three values involved in application of relief angles; affinity factor; feed and depth of cut; chip control; economics.

These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.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DIRECT ACTION POWER STEERING — The only truly direct-action Power Steering units available.
MONROE SWAY BARS—Specified as standard equipment on 15 makes of passenger cars.
E-Z RIDE SEATS—Standard on more tractors than all other seats of this type combined.
MOLDED RUBBER PRODUCTS — Precision-built for all automotive and industrial applications.
MONROE AUTO EQUIPMENT COMPANY
Monroe, Michigan—World's Largest Maker of Ride Control Products

Beech Target Drone Is All-Metal Construction

Based on talk by

JAMES F. REAGAN

manager, missile engineering, Beech Aircraft Corp.

(As reported by K. W. Rix, SAE Wichita Section Field Editor)

THE Beech KDB-1 target drone—the fastest performing piston-powered drone now in existence—will soon go into operational service with the Navy. Fig. 1 shows one of the first of these drones.

The KDB-1 drone is all metal in construction, using standard aircraft structural practice. The aerodynamic load factors used were those of fighter aircraft and, since the drone will be landed by parachute, the fuselage and equipment are capable of withstanding approximately 40*g* impact loadings. The design life of the bird is 25 hr.

The wing span is about 12 ft to the center of the tip pods. The fuselage diameter is not quite 18 in., and the length is 162.5 in. The drone weighs approximately 600 lb. It is powered by a 120 hp McCulloch 2-stroke engine with a turbosupercharger. The whole power pack, including supercharger and all plumbing, weighs 150 lb.

The powerplant drives a constant-speed propeller developed at Beech. This propeller is unique because, being driven from a 2-stroke engine, there is no lubricating or electrical system available for automatic control. The control unit is completely self-contained in the propeller.

The drone is recoverable by means of a parachute, which deploys aft out of the tail. The parachute is 40 ft in diameter.

The drone is remotely controlled from either a ground or airborne station and has a control range of at least 50,000 yd. The bird has a 3-axis control system, but it moves only two sets of surfaces, the ailerons and elevators. A constant course is maintained by the use of an autopilot. The autopilot consists of servo-actuators, which drive the surfaces, a vertical gyro for pitch reference only, a position and rate gyro, which is canted so as to sense deviations in roll and yaw, and a mixer box amplifier.

The missile has been designed to float in water for a minimum of one hour. This was accomplished by filling the wings and wing tip pods with plastic foam material of about 2 lb per cu ft density. All equipment in the drone is completely watertight.

There are corner radar reflectors in the wing tip pods and a rearward looking reflector in the tail cone. These amplify the radar appearance of the drone, which permits passive radar tracking techniques. In order to get visual indication of the drone location, a smoke generator is installed which feeds oil into the exhaust manifold.

The two launch techniques employed are, from the ground on an AT-3 compressed air catapult, which fires the drone at a 15*g* acceleration, and air launching from an airplane.

The target drone has a stall speed of

Continued on page 107

Fig. 1—Beech XKDB-1 target drone will soon go into operation service for Navy.

about 70 knots and a maximum speed of 286 knots. It has an operational altitude of 40,000 ft.

Work is now being done to make the drone adaptable for reconnaissance activities. This vehicle has potential use for both photographic and television reconnaissance.

It Isn't Easy to Make Piston Seize on Purpose

Excerpts from talk by

LEO J. LECHTENBERG
Briggs & Stratton Corp.
(Presented before SAE Twin City Section)

AFTER our Model 6B engines had been in service for a while, we received some complaints regarding the cylinder boxes scoring on the engine in a very short period of time. In most of these complaints we found that the piston would seize in the cylinder in the first few minutes of operation. This was in spite of the fact that every engine had been tested in our plant before being shipped and we had never been able to seize one of these engines either on the test line or during our tests. The percentage that gave us trouble was extremely small, in the category of much less than 1/10 of 1% of our production. However, it was annoying and it was quite a challenge to try to determine the difficulty.

To determine the durability of these engines, we ran over 80 different kinds of tests in an attempt to seize up a piston into a cylinder bore. We were never successful in actually seizing one similar to the way we had received a few of these engines from the customers.

Among the many things we tried were oversize pistons in the cylinder bore. We ran one engine with only 0.0005 clearance in the bore. This engine was run at wide-open throttle and pulled 2.2 hp at 4000 rpm for one hour. After taking the piston out of the engine, we found it to be in a very satisfactory condition.

Among other things we tried, we put aluminum lamination chips in the oil to simulate pieces of laminated aluminum, which might have peeled or broken off the crankcase or any other aluminum part. We nicked the skirts of pistons before and after chrome plating and ran the engines. None had any effect. If the nick was large enough we would cut a groove in the cylinder wall and that was all that would happen.

We ran undersize pistons, made the bottom of the skirt of the piston very sharp, also the top edges sharp before plating to see if we could get the pistons to dig into the cylinder. These pistons were run with 0.0065 clearance between the skirt and the bore. We

Continued on page 108

could still get no trouble.

We also seriously misaligned the pistons with the connecting rods and still could get into no trouble. We took cylinders with burnt plating, peeled plating, and almost any other kind of plating defect. We were still unsuccessful in getting a piston to seize in the cylinder. We also ran a great variety of cylinders not heated versus heat-treated and with various defects on the chamfer on the cylinder bore and on the bore itself.

We took chrome-plating chips which we secured by machining the chrome-plated pistons and put them behind the compression and the oil rings, ran the engines, and still had no results. We took pistons which were not completely covered with plating, ran them at 7500 rpm, wide-open throttle for 5 min, with still no results.

We took engines right off the assembly line, opened them up at wide-open throttle, 7500 rpm immediately and still could not score any cylinders. We were never successful in tying up a bore in the manner encountered in the field. We even ran the engines without oil. We tied up the connecting rod instead of the bore. At this particular time we still could not tie up a piston in a bore no matter how hard we tried.

On some tests about a year later we were successful in getting a piston to tie up in the bore when we ran it without oil, whereas on our previous tests the connecting rod had always tied up first. There were, however, a number of things which pointed to the difficulties which had given us trouble. Among these were defects in plating and in the sharpness of the edges of the piston skirts and in nicks from handling pistons.

We improved our methods of handling pistons, increased the thickness of the chromium on the skirt, improved the quality of the chrome plating, and apparently cured most of our trouble.

Rapid Weathering Tests For Paints Could Be Better

Based on paper by

M. M. GERSON

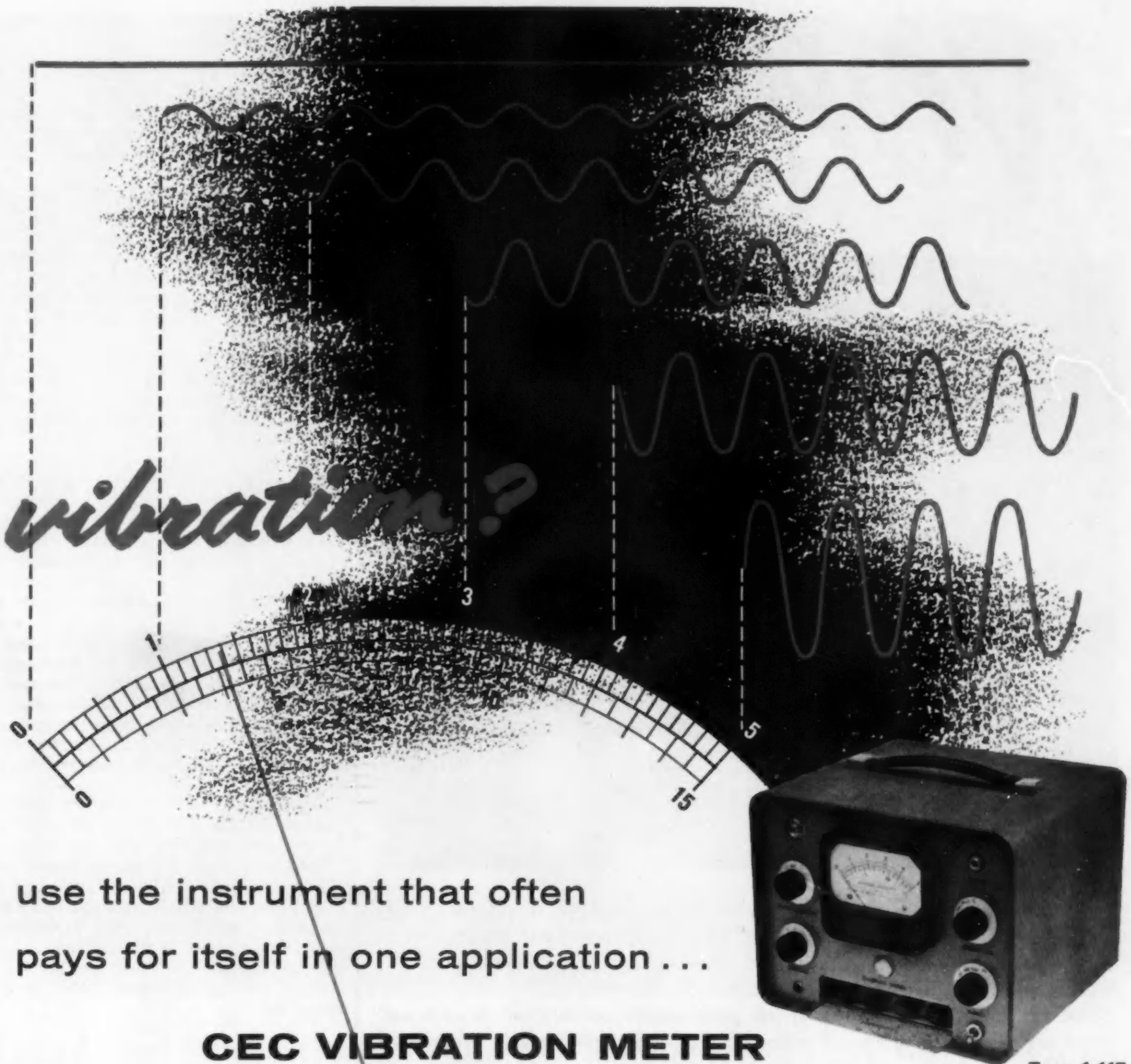
Ford Motor Co.

STRENUOUS efforts to speed up the 12–18 months Florida weathering tests for paints are only partially successful to date. Individual work by every automobile company, plus joint work through the Detroit Paint Production Club lead to these conclusions:

(a) Paints of the same base formulation can be evaluated in reference to each other by standard accelerated weathering devices.

(b) Paints of dissimilar composition cannot. No one has yet been able to set up standard exposure conditions

Continued on page 110



use the instrument that often
pays for itself in one application . . .

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Type 1-117

When control of vibration is critical, CEC's 1-117 Vibration Meter is one of the best investments your company can make. Extremely versatile, accurate and rugged, the portable 1-117 is recommended for any vibration analysis where 115 volt, 50/60/400-cycle a-c is available.

Case histories prove this quality instrument quickly paid for itself many times over in laboratories and jet-engine production and overhaul facilities . . . more than doubled machine tool life by pinpointing vibration amplitudes of less than 0.0001″.

PROVIDES DIRECT READINGS of average velocity and either linear or torsional peak-to-peak displacement on a large, easy-to-read meter. Output may also be connected to an oscilloscope or oscillograph for more detailed wave-form study.

FEATURES 4 INPUT CHANNELS with individually adjustable sensitivity . . . interchangeable high-pass filters for low-frequency cut-off . . . highly stable amplifier. The 1-117 is also adaptable to rack mounting. The only external accessories needed are suitably matched, self-generating pickups.

For complete specifications, please write for Bulletin CEC 1538B-X19, or contact your nearby CEC field office.

Consolidated Electrodynamics

CEC *300 North Sierra Madre Villa, Pasadena, California*

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that will eliminate the variables of Florida weathering.

Indicative of the reliability of accelerated devices to evaluate paints of similar resin and pigment compositions is inclusion by American Motors of a Twin-Arc weatherometer cycle in its paint specifications.

Ford has found that the new high melamine content enamels show little or no correlation between Florida weathering and accelerated exposures in the cycles normally used.

Ford also has established a cycle for masonry paints that was fairly successful. Cement blocks were coated with the paints to be studied and exposed successively to: (1) immersion in water; (2) freezing, at 0 F; (3) Exposure to an S-1 sun lamp in repeated cycles.

Chrysler, in a new report, indicates that electron microscope studies of accelerated exposure panels of synthetic enamels with titanium oxide pigments show the same type of failure that was found on Florida panels. However, the rate of failure due to artificial weathering of organic pigment systems was much slower than Florida weathering.

General Motors is concentrating on the effect of variation of the cycle of water to light in accelerated testing devices. Their work indicates that exposure to light at various relative humidities may account for some of the inconsistencies noted in Florida exposures.

The status of accelerated weathering of paints remains that of a tool to be used with the greatest care.

(Paper "The Status of Accelerated Weathering of Automotive Organic Coatings" on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

High Temperatures Limit Logging Trucks' Brakes

Based on paper by

HENRY N. ARD

Potlatch Forests, Inc.

FACTORS which limit or reduce the maximum capabilities of the drum-type friction brakes used in logging truck application include:

1. Lack of an adequate and practical means of heat dissipation.
2. Fadeout at high brake drum temperatures.
3. Excessively high lining and drum wear rate as their temperatures exceed 300 F during brake applications of long durations.
4. Damage to tires from high brake drum temperatures.
5. Damaging effects of cooling water if not properly applied.

Continued on page 112

6. Necessity of special tools and procedures when doing minor maintenance work in order to prevent brake unbalance.
7. Damaging and unbalancing effects of dirt and abrasives which can easily enter the brake drum.

The single factor listed above which would produce the greatest results if eliminated is the first. Providing adequate and practical brake cooling automatically eliminates all of the other factors except 6 and 7. Heat dissipation should be sufficient to maintain temperatures below 300 F.

The dispersion, location, and physical property of the many brakes on a logging truck create many problems which must be overcome in providing an adequate and practical means of cooling brake drums and linings. In view of this, it appears to be more practical to supplement the existing friction drum brakes with a single centrally-located retarding brake which should be designed to provide capacity to absorb the drag braking necessary to maintain safe speeds on curves and grades.

This absorption-type brake might receive the necessary cooling from the engine cooling system and should be light, easy to install and operate, and provide a means of easily regulating the absorption capacity to meet changing requirements.

(Paper, "Friction Brake Limitations in Logging Truck Service," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Automotive Diesel Will Stay on the Make

Based on paper by

BERNARD UCKO

Mack Trucks, Inc.

THE diesel's superiority is assured for a long time to come, thanks to its unsurpassed fuel economy, outstanding reliability and longevity. But there will be even greater advances made, such as:

1. An increase in bmep.

2. More efficient engine configurations.

3. Higher rotative speeds.

4. Use of lighter metals.

5. Improvements in fuel injection and combustion process.

6. Adoption of hydrodynamic torque converter.

Increasing the bmep will reduce weight and bulk. This will be accom-

Continued on page 115

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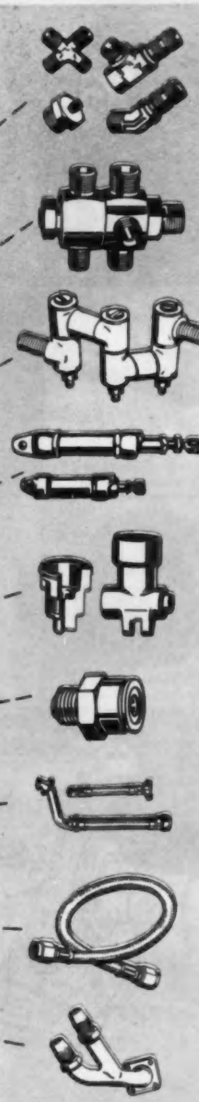

For light weight, simplified configuration, and compactness in the fluid system you design . . . depend on Weatherhead fittings and components every time.

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plished through forced induction and particularly turbocharging. The application of turbocharging to engines of variable speed and in the speed range of engines for commercial vehicles is relatively new and improvements are to be expected in efficiency, size, and response to changes of speed and load.

More efficient engine configurations will further reduce weight and bulk. Multibank arrangements lead almost automatically to more compact and lighter structures. This invites the use of lower stroke/bore ratios, permitting higher rotative speeds without increasing the mean piston speed.

Engines can be built lighter by using more light metals. Combinations of ferrous weldments with light metals may result in lighter structures than can be obtained by either technique alone.

While specific fuel consumption is now rather satisfactory, there is reason to believe that it will be made still better through further insight into fuel injection and the combustion process.

The torque-speed characteristics of turbines are theoretically better suited to vehicle operation than those of reciprocating internal engines, but gained at the sacrifice of efficiency. The diesel, equipped with hydrodynamic torque converter in combination with a gear transmission, can achieve just as suitable if not better characteristics with simpler and less costly means.

(Paper "The Future of the Diesel Engine in Commercial Vehicles," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price 35¢ to members; 60¢ to nonmembers.)

New Test Evaluates CO Concentration in Cars

Based on paper by

D. G. FOWLER

Chrysler Corp.
Chairman, AMA Carbon Monoxide Special Group

THE Vehicle Combustion Products Subcommittee of the AMA has drafted a measurement procedure for evaluating CO contamination in an automobile passenger compartment.

The main purpose of this procedure for manufacturers appears twofold. First, it should be of assistance to engineers and designers in evaluating the effect of various changes on possible exhaust gas contamination of the passenger compartment. Second, it should aid quality control engineers in their evaluation of production models. It is not suggested that this test procedure

Continued on page 117

replace other tests such as water and smoke tests for body leaks, but it should prove a useful adjunct for those concerned with such matters.

Procedure for Checking CO Concentrations In the Passenger Compartment of Motor Vehicles

1. Instrumentation:

It is suggested that, where available, National Bureau of Standards type colorimetric CO indicating tubes or equivalent be used and that readings be taken in the passenger compartment at approximately the driver's head level. (Colorimetric indicating tubes are suggested because of their accuracy, availability, and convenience in use. Other instruments such as the hopcalite and infra-red may also be used.)

2. Test Conditions:

An adequate number of readings should be taken under the following conditions:

a. With the car idling:

Windows—all of the car windows should be closed except the front vent windows which should be open on both sides about 30 deg. Tests should also be made with the vent windows closed.

Heater—readings should be taken with the blower off and the fresh air vent closed and also with the blower operating at high speed and the fresh air inlet to the heater open.

Car location—the tests should be made outside in an area where there is a minimum amount of environmental CO. The car should be positioned for the idle test so that it is exposed to any wind that is present, essentially directing exhaust towards the vehicle.

(In running the idle checks periodic readings should be taken until the CO concentrations are stabilized. It has been observed that under this test condition and with a steady wind blowing toward the rear of the vehicle it becomes necessary to close the vent window which is on the side of the exhaust pipe. For example, in a vehicle having a right side tail-pipe, exhaust gases may follow almost a direct path into the vent window open on the right side thus resulting in an unduly contaminated vehicle. This test will often demonstrate a dramatic removal of contamination when the heater blower is turned on after exhaust gases are found to be present in the vehicle.)

b. With the car travelling at 30 mph and 60 mph:

Windows—same as for idle test.

Heater—same as for idle test.

Driving conditions—the car should be driven over a closed circuit so that there is an opportunity to obtain readings with the wind hitting the car from various directions.

3. Information to be Recorded:

a. Make of car.
b. Model.
c. Engine type.
d. Location of tailpipe outlets.
e. Wind velocity.
f. CO present in the exhaust.

In general this procedure is devised as a minimum test for assessing the contamination of the vehicle by its own exhaust gases. It is considered a practical procedure, having been in use for over a year by American car manufacturers and already adopted as an official test procedure by some.

(Paper, "Development of a Test Procedure for Measurement of Carbon Monoxide in Automobile Passenger Compartments," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

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Instruments Aid Car-Ride Evaluation

Based on paper by

R. R. PETERSON

Ford Motor Co.

PASSENGER-CAR ride evaluation has expanded to include many periodic disturbances. Instrumentation is finding ever-increasing use in the evaluation of these factors. Extremely important still, however, is the human evaluation of car ride. It is in this area where instruments can make their greatest advances—as supplements to human evaluation.

Working out a good basic ride is a relatively cut-and-dried business. The ride man's principal difficulties stem from expansion of his activities to include just about any periodic disturbance that can be felt, heard, or seen. Harshness, road noise, engine noise, driveline roughness, sheet-metal shake, and axle whine are some of the problems which require consideration.

These new problems may be less serious than their predecessors but they are invariably more complex and require evaluation of progressively smaller differences. Therefore the trend to greater use of instrumentation.

Table 1 lists some of the laboratory performance tests used in ride evaluation.

In road testing, human beings remain the favorite ride instrument, and they have numerous shortcomings. No two specimens are alike. Their readings are purely relative, never absolute quantities; therefore, it is difficult for them to distinguish small differences. They are often required to utilize not-too-dependable sensory memories to make comparisons. They are strongly affected by environmental influences—state of digestion, emotional disturbances, and fatigue, for instance. Calibration is very difficult and worst of all, a human being has, on occasions, an unfortunate tendency to be a little less than strictly impartial.

Many of these defects can be minimized. Adequate calibration can usually be obtained through conscientious use of standard reference vehicles. Group tests or jury rides improve accuracy to a marked degree, especially when the so-called blindfold technique is applicable. At any rate, the human instrument can lay claim to one outstanding virtue: he evaluates directly in terms of customer response.

Other instruments require two distinct operations, measurement and interpretation. The latter involves a human agent, often a qualified ride man. As long as ride evaluation remains a highly subjective affair (and that will be until exploration of its psychomechanical and psychoacoustical aspects has proceeded far beyond the present point) the ride man's job is in no immediate jeopardy.

The attention of instrument engineers is being directed to a territory where opportunities are almost unlimited—the use of instruments as supplements to, rather than replacements for, manpower. Instruments are ideally qualified to compensate for such human deficiencies as the poor sensory memory. For instance, the use of tape recorders has greatly simplified and improved the performance of tasks like exhaust system tuning. The human ear, rather than instrument readings, is still relied upon to judge between various installations but the judging process takes place under almost perfect listening conditions, with the memory requirement practically eliminated. Moreover, an audition can be repeated exactly, whenever desired. Similarly, the new compact closed-circuit television unit permits seeing what goes on in those out-of-the-way places under the car or in the engine compartment.

It has often been stated that of all the tools available for ride evaluation

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Table 1—Laboratory Performance Tests Used in Ride Evaluation

Unit Tested	Type of Test	Information Provided	Related Ride Activity
springs, linkages	static and dynamic load-deflection	static and dynamic rate patterns, energy dissipation	basic ride, harshness
springs, linkages	drop-weight	time—displacement ("decay") curves	harshness
shock absorber	dynamometer	work diagrams (force-displacement)	ride tuning
frame, frame and body	static torsion and bend	structural rigidity	shake, harshness
vehicle	static load-deflection in ride and roll	static ride and roll rate patterns, energy dissipation	basic ride, handling, cornering
vehicle	bump rig shake rig	frequency response patterns—selected components or locations	shake, harshness, road noise, axle hop, wheel fight

and development, a road trip is the most effective. After a few days of traveling, 6 or 8 people in 3 or 4 cars will bring back all kinds of useful information, with remarkable agreement between the various observers. But even more remarkable is the contribution to such a trip, by way of time saving, accuracy, and convenience, which a modest quota of instruments can make, especially if it includes 2-way radios and a dictograph as well as a few simple items like accelerometers and suspension bumper-contact indicators. To participate in a well equipped and well conducted ride expedition is truly a revelation. Experiences of this kind will convince even the most skeptical old-time ride man that instrumentation is here to stay.

(Paper, "A Ride Engineer's Experience with Instrumentation," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Salt Spray Test Modification Ready

Based on paper by

W. L. PINNER

Houdaille Industries, Inc.

A NEW acetic acid modification of the salt spray test (ASTM B117-54T) and a "Corrodkote" test are being readied for widespread use in testing of plated coatings. Aimed to overcome valid objections to the long used—and often misused—salt spray test, these new procedures nearing agreement are resulting from a Research Project of the American Electroplaters Society.

Acetic Acid Modification

The proposed acetic acid modification of the salt spray test differs from the latter in two important respects:

1. The solution sprayed onto parts contains acetic acid in addition to salt in water. (This produces rather faithfully the types of corrosion which occur in service on copper-, nickel-, or chromium-plated parts.)

2. Limitations far beyond those specified by ASTM have been imposed on designation of equipment; actual method of conducting the test; restrictions on its conditions; statistical methods of sampling; and statistical analysis of test results. (Detailed data on these limitations appear in three AES Project Committee reports by W. L. Pinner: in 1953 AES Proceedings; in the August, 1955 issue of *Plating;* and in 1956 AES Proceedings.)

Otherwise the proposed modified procedures are somewhat similar to those of the familiar salt spray test.

The "Corrodkote" Test

In the "Corrodkote" procedure, surfaces are made wettable by rubbing with an abrasive compound mixed with specific chemicals to form a paste. Then the paste-coated article is subjected to high humidity under controlled conditions. This results in an accelerated attack on the plated part.

The abrasive used is called kaolin—a pure clay which has no chemical effect on the plated coating. The "Corrodkote" formula is as follows:

Cupric Nitrate, g	0.035
Ferric Chloride, g	0.165
Ammonium Chloride, g	1.0
Kaolin, g	30.0
Water, ml	50.0

Use of "Corrodkote" results in a type

Continued on page 122

and extent of corrosion on known thicknesses of copper-, nickel-, and chromium-plate which exactly duplicates the type and extent of corrosion which occurs in Detroit—especially in the winter time.

Either one or both of these tests may be the measuring stick by which the plating industry can make further progress from both quality and economic standpoints.

(Paper "Recent Developments in Accelerated Testing of Plated Coatings," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

Marine Supercharging Ups Output, Saves Fuel

Excerpts from paper by

F. S. DRISCOLL

Detroit Diesel Engine Division, GMC

(Presented at SAE New England Section)

WHEN marine engines are turbocharged to increase output, specific fuel consumption is improved as well. Fuel economy can be increased, in fact, about 12% when turbochargers are used principally to improve fuel consumption at fixed output. Fig. 1 illustrates this.

Workboat engines can obtain substantially the same fuel economy, however, without turbocharging, because they are conservatively rated for long life. The new engine parts required for turbocharged engines can be incorporated in a nonturbocharged engine that is designed for maximum fuel input equal to that required for continuous duty ratings only.

Fig. 2 shows that both the turbocharged and "tailored" engines are about equal in performance at these ratings. The reason: exhaust gas energy is negligible; therefore difficult to recover. Moreover, turbocharged engines, as they exist today, present certain installation problems, especially in the exhaust system area, which preclude their usage in workboat service.

(Paper, "Application of Diesel Engines to the Marine Industry," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

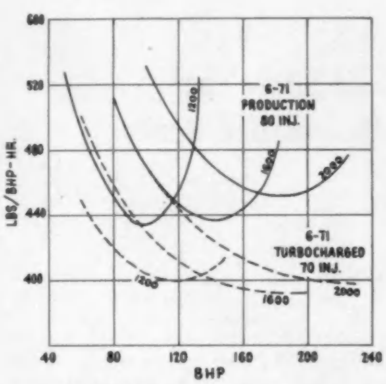

Fig. 1—Turbocharging for economy.

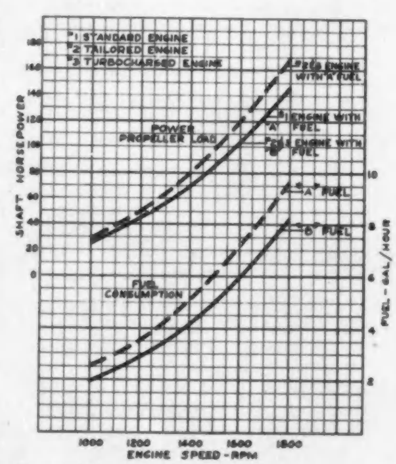

Fig. 2—Turbocharging effect on workboat engine.

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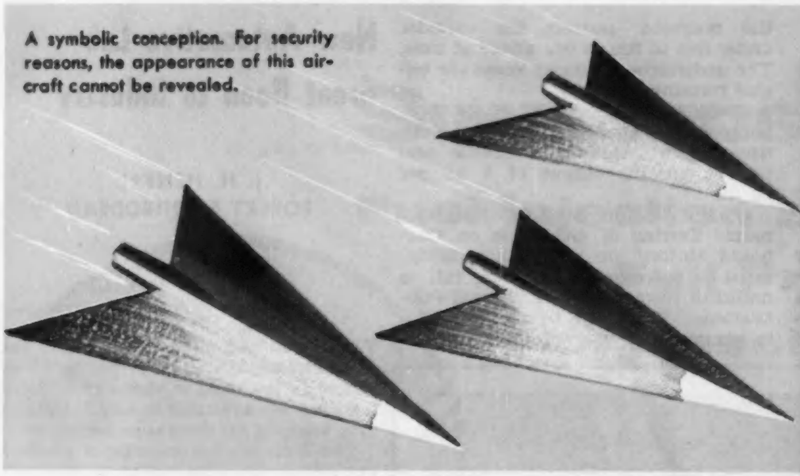

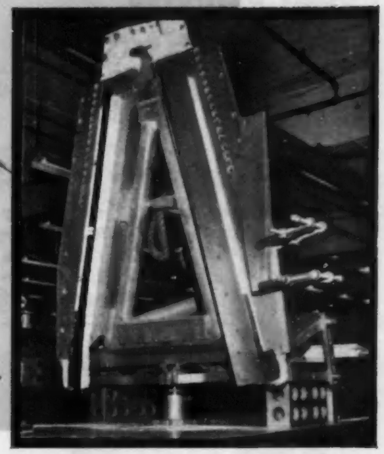

A master drill and setting gauge, showing use of Epon resins to duplicate compound curves and contours.

In building the supersonic Arrow . . .

Avro Aircraft, Limited saves time and money with

EPON® RESIN

dies, tools, jigs, molds and fixtures

Avro Aircraft, Limited—developing Canada's supersonic Arrow—is achieving major savings with Epon resin tooling.

Epon resins provide faster, lower cost preparation of stretch dies, forming tools, drop hammer dies, jigs, duplicate master die molds, checking and assembly fixtures. Avro reports that in making dies of Epon rather than metal, manpower requirements are two-thirds less, which is reflected in correspondingly great savings in the unit cost of tooling.

The Epon resins have an ideal combination of properties for tooling applications. To list just a few:

- Exceptional dimensional stability, high impact strength, excellent resistance to abrasion, minimum residual stress in cured parts.
- Ease and speed of preparation.
- Low shrinkage in filled formulations, assuring perfect master reproduction; minimum warping and stresses.
- Adaptability to repairs and design changes.
- Minimum finishing requirements for smooth surfaces.

Like Avro, other leading manufacturers report savings as high as 80% with Epon resin tools and dies—for *production* as well as experimental and short-run work. Can you make comparable savings in your own operations? Find out by writing for technical literature on Epon resins for tool and die applications.

Epon-faced die requires only hand rubbing to achieve smooth finish. Radii are being touched up with sander.

Stretch die, with Epon resin facing of involved contours, ready for run on 800-ton press.

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Pistons Destroyed In Preignition Tests

Based on paper by

KENNETH ROBINSON,

Scott Atwater Mfg. Co.

(Presented before SAE Twin City Section)

PISTON burning is being studied by the Scott Atwater Mfg. Co. by inducing preignition in one cylinder of a 2-cyl outboard engine. Preignition is forced by breaking the primary lead in the magneto, causing the cylinder under test to fire 45 deg ahead of time. The undisturbed cylinder keeps the engine running.

Piston burning is critical in outboards since they often operate continuously at wide-open throttle and have a specific output of 1 hp per cu in.

(Paper "Piston Burning—Hydrodynamic Testing of Gearcases on Outboard Motors" on which this abridgment is based is available in full in multilith form from SAE Special Publications. Price: 35¢ to members; 60¢ to nonmembers.)

New Automotive Lab Great Boon to Industry

Based on paper by

J. H. HENKEL
ROBERT E. THIBODEAU
and
GEORGE A. TUTTLE

Detroit Arsenal

THE new automotive laboratory at the Detroit Arsenal provides facilities which do not exist in industry. These facilities are available to any industrial firm working on Ordnance contracts.

The facilities are capable of rendering full support on research, development, and qualification tests involving internal-combustion engines, transmissions, and full-scale vehicles. There are six engine cells and facilities which cannot be found elsewhere at this time, namely, two transmission cells, a vehicular test cell, and electronic-type instrumentation permitting rapid scanning and print-out of up to 400 test variables.

Engines can be tested to determine their performance, to evaluate fuel systems (carburetor or injection) or ignition systems to conduct vapor-lock studies, to perform fuel and lube research, and the like (Fig. 1).

The transmission cells (Fig. 2) are ideally equipped to investigate transmission performance, efficiencies, and heat rejection over the entire speed range from stall to top speed.

The vehicular test cell (Fig. 3) makes it possible to determine power output and efficiency of entire vehicles under simulated field conditions, to conduct cooling performance studies, and to test all types of components. Test time

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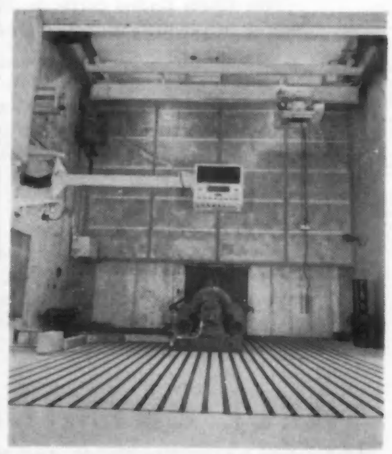

Fig. 1—One of the six engine test cells. Each cell is an independent unit, 25 x 40 x 24 ft in size, with control room adjacent.

will be reduced because much of the test work now conducted in the desert or other field installations can be performed in this cell. Better test information will be gained because better control of test variables (speed, load, wind velocity, and direction) is available. However, the use of the vehicular test cell is not limited to this type of work. Human engineering problems can be worked out, crew compartment and ventilation studies can be conducted, and the performance of radar systems or other equipment under high-temperature conditions can be investigated.

The laboratory can be adapted easily to test turbines or other unconventional engines, and when nuclear powerplants become feasible for automotive application, certain design features of the installation will facilitate testing them.

(Paper, "The New Automotive Laboratory at Detroit Arsenal," on which this abridgment is based is available in full in multilith form from SAE Special Publications, 485 Lexington Ave., New York 17, N. Y. Price: 35¢ to members; 60¢ to nonmembers.)

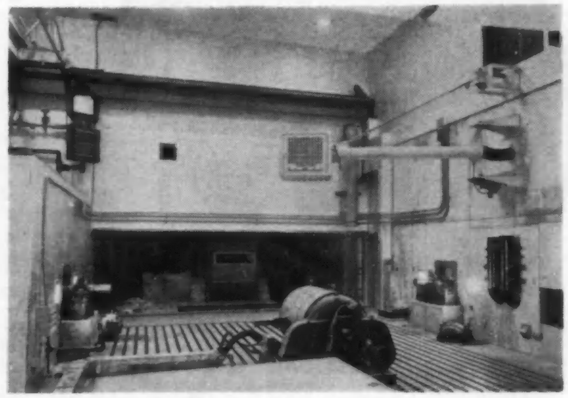

Fig. 2—Test cell for transmissions, especially of the cross-drive type. Each of the two cells is 26 x 45 x 25 ft in size, with control rooms located on floor above to afford full visibility.

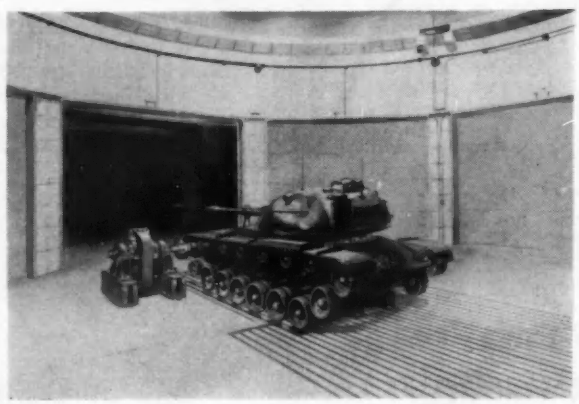

Fig. 3—Vehicular test cell (80 ft in diameter and about 45 ft high) is designed primarily for testing of military combat vehicles under simulated field conditions.

Accelerated Tests Can't Predict Life

Based on article by

R. S. DALRYMPLE

Reynolds Metals Co.

CAREFULLY chosen and properly designed accelerated tests can, and do, guide the engineer to choose the right alloy and coating technique for each design. These tests usually will tell him the combination of variables which will lead to longer service life. But only actual exposure will tell him *how much* longer.

Accelerated corrosion tests, in other words, are useful characterization devices. They will not predict a material's ultimate service life.

The place of honor among difficult-to-analyze tests goes to the short-term environmental study. This type of experimentation often leads to erroneous conclusions backed by seemingly ironclad logic.

The operator of such a test program can tell his critics that he has not fallen into the pitfalls of the accelerated test, since he has not doctored the environment. But to illustrate what happens when the time variable is tampered with, let us examine the data obtained in a typical environmental

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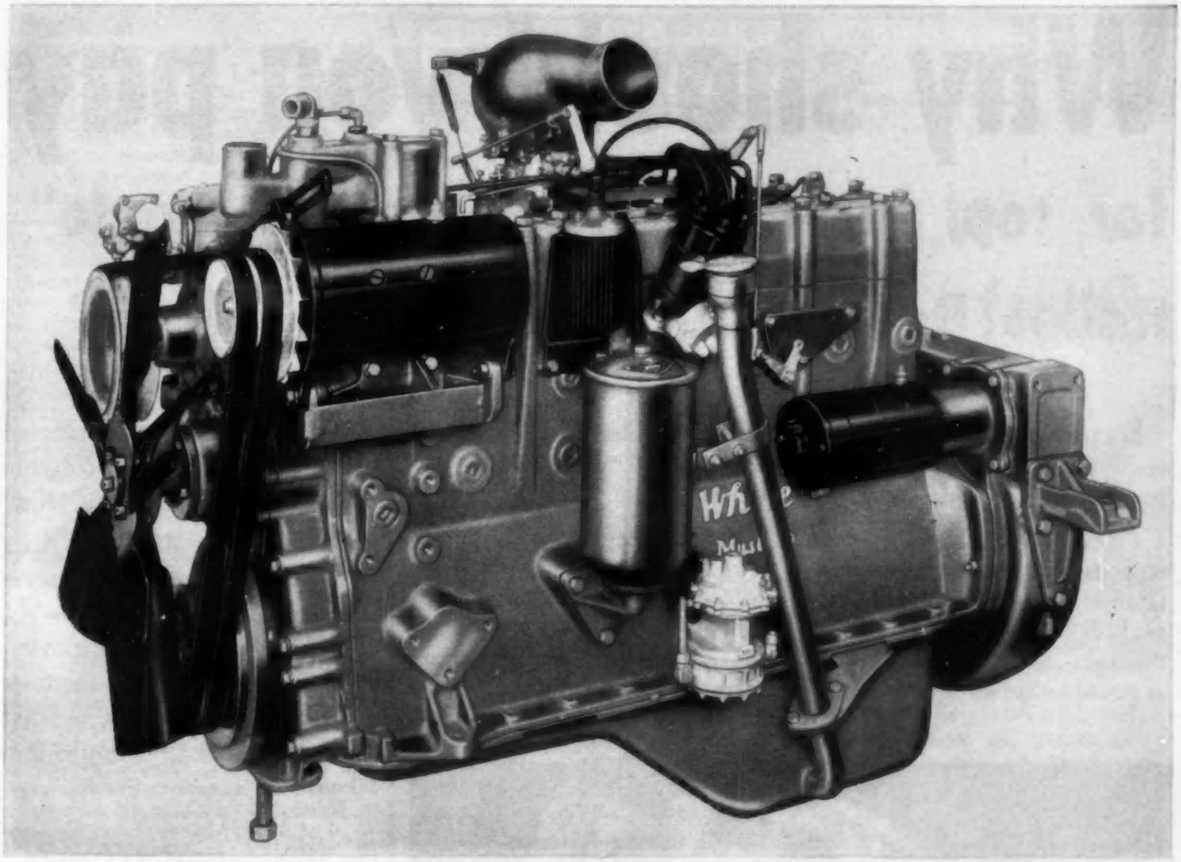


The 400-Mustangs drive White's 3000, 4000, and 9000 series tractors. In these vehicles they are giving outstanding operating economy . . . due in part to White's use of Nickel cast iron blocks.

Newest White Mustang!

Extra strength of Nickel cast iron gives her extra "go"

This is a powerful, rugged engine . . . built for maximum "go" with minimum maintenance in day-in, day-out tractor trailer service.

White Motor Company builds it. It's one of their new 400-Mustangs (145, 160, 200, 215 HP). As in earlier Mustangs, blocks for the long-lasting 400s are made of a Nickel cast iron.

Nickel cast iron meets 4 design needs

White's traditional reliance on Nickel cast iron blocks for the Mustangs is soundly based on four design needs.

Extra strength Nickel cast iron gives the light, "pillar—type" Mustang block the extra strength needed for long, reliable heavy-duty service.

Pressure tightness With Nickel cast iron the complex block can be reliably cast with the pressure tightness needed in these high compression engines.

Extra wear resistance Nickel cast iron provides the improved wear resistance for this powerful engine.

Machinability Nickel cast iron gives White fast, easy machining. Its high strength is not obtained at a sacrifice in machinability and production costs are held down.

INCO NICKEL

From the fleet operator's view point . . . The light weight Nickel cast iron blocks in the Mustang improve operating economy, reduce maintenance and replacement costs, cut road side repairs.

If you buy or build internal combustion engines, look into the advantages of Nickel iron castings . . . for blocks, heads, flywheels, crank cases, camshafts, manifolds and other parts. Write for Inco's helpful "Guide to the Selection of Engineering Irons."

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

INCO

corrosion test.

Fig. 1 represents the corrosion rate of aluminum alloy 1100 in an industrial atmosphere during a period of 20 years. Note the high initial corrosion rate and the manner in which the rate of penetration drops off with time. It is obvious that the true performance of alloy 1100 could not be predicted from the data obtained after the first few months or even the first years of exposure.

According to the data after two years of exposure, the corrosion rate is 2 mils per year. Had corrosion continued at this rate for 20 years, the sample would have been reduced in thickness by 0.040 in. The actual maximum depth of attack for this alloy was only 4.5 mils in this period, only about one-tenth the loss predicted by the early measurements. This illustration should place a reasonable doubt as to the validity of short-term tests or at least of making long-term predictions on short-term data.

What purpose then have accelerated tests . . . why obtain short-term results?

In general, accelerated corrosion tests performed under carefully chosen conditions can develop significant differences in the basic behavior patterns between alloys of a given class. For example, one might study the behavior of different aluminum alloys in a salt spray test and determine fundamental differences in behavior as related to marine environment.

Although significant differences in corrosion rate or in type of attack are obtained in the laboratory, these data cannot be expressed qualitatively as differences in performance in the field. There are accelerated tests designed to show the tendency of an alloy to stress corrosion or intergranular corrosion, or to compare the susceptibility of several alloys to such attack. But the test does not say that such attack will occur . . . only a tendency exists. Accelerated tests are characterization studies and usually do not yield absolute data which, beyond coincidence, can be extrapolated into long-term results.

(Paper, "Accelerated Tests for Anodic Films," on which this abridgment is based is available in full in mulitlith form from SAE Special Publications. Price: 35¢ to members; 60¢ to nonmembers.)

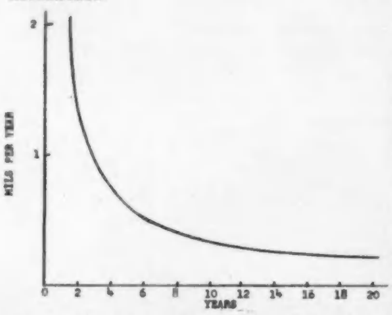


Fig. 1—Corrosion rate of alloy 1100 sheet (0.064-in. thick) exposed in an industrial environment for 20 years.

New Members Qualified

These applicants qualified for admission to the Society between July 10, 1957 and August 10, 1957. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

Ralph Pogson (A).

British Columbia Section

Ralph Faulkner (A).

Buffalo Section

Claude V. Hawk (M), James F. Muir (J).

Canadian Section

Herbert V. Coleman (A), Charles A. Hatchard (A), James N. Matthews (J), A. J. Renwick (M), Gordon F. Ritz (A), Allen Grant Warner (M).

Central Illinois Section

Robert L. Grover (J), Jack M. Tollefson (M).

Chicago Section

Stanley J. Adams (A), Arthur R. Bonvouloir (J), E. P. Epler (M), Sidney Allen Heenan (M), Joseph R. Kirk (M), Frank J. Kozumplik, Jr. (A), Richard L. Lewis (M), David C. Miller (M), Horace W. Neill (A), L. L. Duke Norman (A), John E. Onnen (M), Arthur J. Peters (M).

Cincinnati Section

John E. Gyarfas (M).

Cleveland Section

Cmdr. Philip P. Lucy, USN (M), Albert E. Taylor (M), Robert L. Williams (M).

Dayton Section

Howard R. Otto (J), John W. Spencer (M).

Detroit Section

Sidney Astourian (M), Henry J. Baecker (M), Earl M. Barden (M), Edward J. Bayus (M), Raymond Joseph Cedar (J), John K. Dobbyn (M), John L. Frost (M), Earle Harvey Fulford (M), Chester Gieldowski (M), William John Hallauer (J), John C. Hampson (M), Perry B. Hartupee (M), David L. Hill (M), Harvey G. Humphries (M), Leo Francis Kasaczun (J), John Molyneaux Lay (J), Cameron Lombard (A), Edward Mark (J), William H. McGraw (A), Jack C. McLauchlan (J), Jack Mohr (M), Sarv D. S. Mongia (J), Ross E. Nielsen (J), J. Doyle Ryan (M), Peter Henry Sayer (J), George Seidman (M), Robert V. Sharkey (A), Richard L. Swart (M), Paul E. Taylor (M), Henry M. Woodhouse (M).

Hawaii Section

James W. Sugimura (A).

Indiana Section

George W. Bruner (M), Richard A. Doversberger (M), Gerald L. Gremaux (M), Jack Lee Grose (J), Robert E. Hoffmeister (J), James W. Kleinschmidt (M), David E. Lucid (M), John Carlton Nordman (M), J. M. Selzer, Jr. (M), Ralph H. Warkentin (J).

Kansas City Section

Charles C. Cochran, Jr. (A), John G. Matalon (M).

Metropolitan Section

Robert L. Burke (M), Joseph S. Cascio (M), Francois Crouzet (M), Frederick E. Graves (M), Robert H. Johnson (M), Frank J. Kowalkowski (M), J. A. McCanney (A), Philip S. Rust (M), Herbert G. Schultz (M), James J. Studenic (J), William Weinstein (A).

Mid-Continent Section

Vaughn E. Flinn (J).

Mid-Michigan Section

F. Robert J. Fowler (J), Edward A. Idzkowski (M), Michael J. Koenig (A), William C. Robertson (M), Oscar E. Sundstedt (M).

Milwaukee Section

Richard A. Burkard (M), Donald J. Surfus (A).

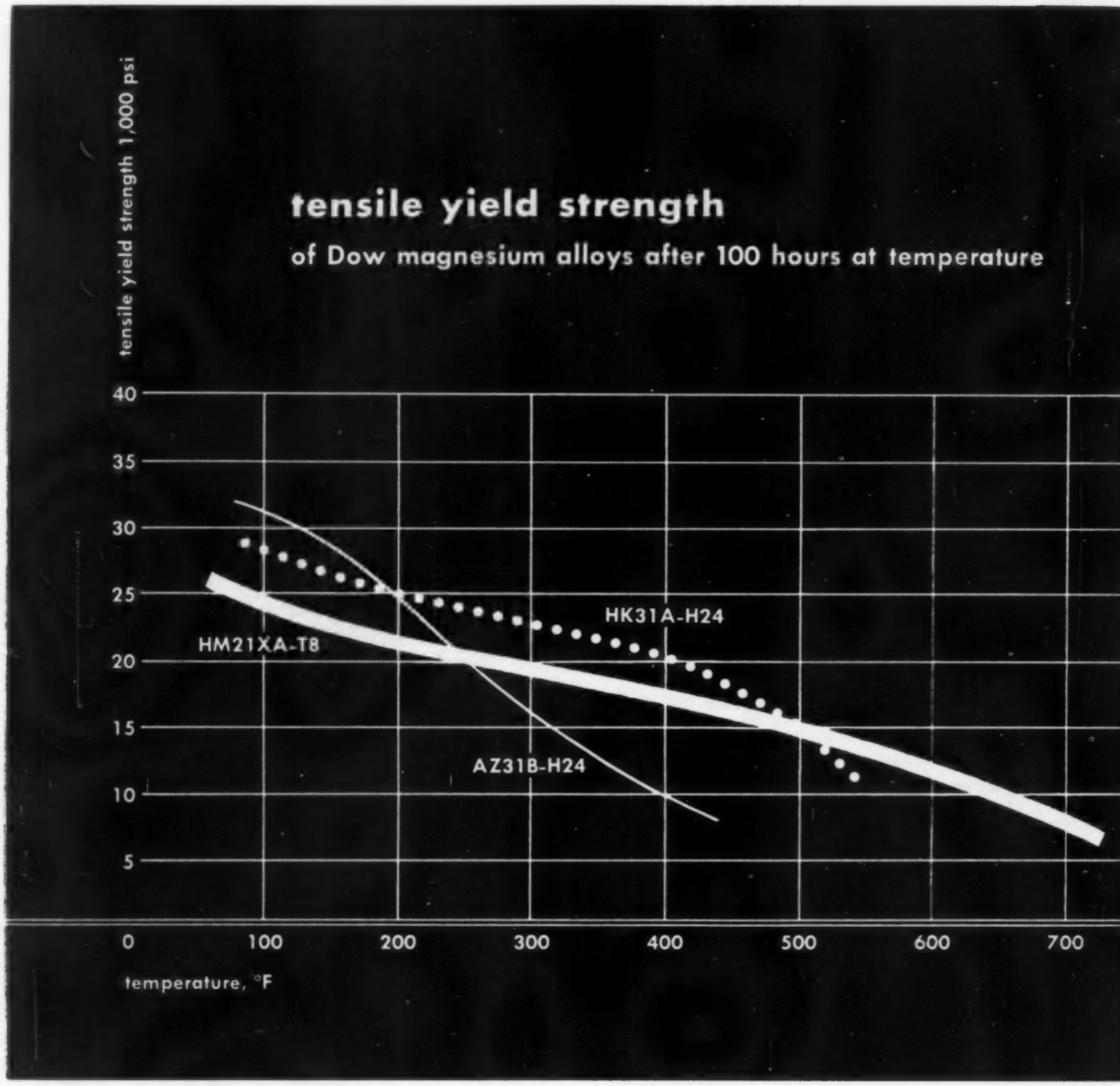
Mohawk-Hudson Section

Clifford E. Bowdish, Jr. (A), Kenneth Earl Parr (M).

Montreal Section

Paul Belair (M), Kenneth C. Rackham (A), Harold Alexander Ross (A), Ronald H. Whiteside (M), Kenneth William Wood (A).

Continued on page 133



New magnesium alloy holds properties for 100 hours up to 700°F.

Dow Magnesium HM21XA-T8 alloy extends further the range of conditions under which light metals can be used in aircraft design. Second in the series of sheet alloys designed specifically for elevated temperature applications, it supplements the excellent characteristics of HK31A alloy.

HM21XA-T8 retains its properties at temperature during long periods of time. Even one hundred hours at 700°F. results in relatively little change in tensile yield, creep and elastic modulus.

Magnesium lightness is combined with strength at elevated temperature in HM21XA-T8, offering new ways to save weight or gain increased rigidity in the design of missiles and aircraft. This alloy is supplied in the -T8 temper and can be formed in this temper without the need for further heat treatment after fabricating. Samples of HM21XA-T8 along with detailed information are available. Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department MA 1400D-2.

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New Members Qualified

continued

Northern California Section

Walter J. Frisch (M), William B. Richards, Jr. (M).

Oregon Section

Arthur F. Dickow (A), Harry W. Dressler (A), Edward L. Kropp, Jr. (A).

Philadelphia Section

George W. Koehn (M), Wallace D. Stein (M), George A. Wallace (M).

St. Louis Section

Albert A. Mueller, Jr. (M), Raymond F. Stelzer (J), M. George Zornada (J).

Southern California Section

Gerald G. Boruski (M), Malcolm Lee Fickel (A), Thomas R. Fisher (M), Joseph E. Havenner (A), Joseph J. Struck (J), T. A. Wilmshurst (A).

Southern New England Section

Robert F. Anasoulis (J), William E. Aksomitas (M), Richard Bell (M), Thaddeus A. Lasek (M), Peter F. Nizen (A), Edward F. Potocki (M).

Spokane-Intermountain Section

Elmer C. Lindahl (A).

Syracuse Section

H. Follett Hodgkins, Jr.

Texas Section

C. L. Harris (M), Jesse B. Holman, Jr. (A), Clifton E. Sadler (J).

Twin City Section

Bernard W. Carlson (A), Louis B. Evans (M), John William Gausman (M), Alexander Kaminski (M).

Washington Section

Lt. Col. George H. Baxter (M), Samuel F. Follett (M).

Wichita Section

Gary C. Himes (A).

Outside Section Territory

Eugene R. Dziadon (J), J. F. Finn, Jr. (A), C. O. Johnson (M), Henry W. Morriss (J), Joseph T. Ream, Jr. (M), Wilbur C. Rumph (J), Ludwig J. Schinnerer (M), Lawrence E. Schwietz (J), Robert P. Wolfe (M), Woodrow I. Workman (M).

Foreign

Svante Rune K. Breitz (J), Sweden; John R. Long, Jr. (A), Venezuela; Peter H. Molyneux (M), England; John Henry Sainsbury (M), England; Kemal Tek'er (M), Turkey.

Continued on page 134

Applications Received

The applications for membership received between July 10, 1957, and August 10, 1957, are listed below.

Atlanta Section

Harry Nelson Edmondson, Charles Harold Rutledge, Jr.

Baltimore Section

D. F. Ryder, Paul R. Shepler.

British Columbia Section

John C. Midgley, Frank M. Smith.

Buffalo Section

John K. Hastings, Myron Allan Seiden, Wallace E. Wilson.

Canadian Section

Theodor William Haiplik.

Central Illinois Section

Donald E. Merritt, Dean H. Skinner.

Chicago Section

Eugene T. Champlin, Robert E. Coates, Owen J. Higgins, Ralph H. Horn, Elbert M. Ladd, Elden LeRoy Mathias Lippo, Hans Moser, Allen Hill Myers, Bernard J. O'Halloran, John Talamonti, Richard S. Wagerson.

Cincinnati Section

John I. Hamilton, Robert A Winblad.

Cleveland Section

F. H. Brysacz, Ralph H. Daugstrup, Sheldon Glickhause.

Colorado Group

Thor B. Groswold.

Dayton Section

Robert Stanton Burns.

Detroit Section

Robert C. Bazzell, Thomas Kenning Brichford, Herbert R. Carrier, Lloyd Keith Covelle, Jr., James W. Craig, James D. Fleming, Ronald Glen Frakes, Richard A. Graves, Ismail H. Hoyi, Ronald M. Kasperzak, John M. Lackner, Robert Hudson McRae, Frank George Mooney, Robert D. Negstad, Martin J. Paliokas, Rolland E. Percival, Alden W. Sears, Roy T. Stake, Lee E. Sutton III, W. L. Tomlinson, Donald A. Wahrman, Donald D. Walker, Henry Tatching Yu, Oreste John Zamparo.

Indiana Section

Arthur Allen Boyers, Earl N. Daggy, Jr., Dwain A. Sylvester, W. W. Ulrich, Donald Lee Willoughby.

Kansas City Section

John R. Steele.

Metropolitan Section

A. Bringewald, Frank H. Brock, Randall H. Carpenter, William Russell Collins, Sr., Deane Fredric Flader, William J. Furlick, Erich A. Herold, Hyman Lewis Kazin, Robert Kurzwell, Roy Samuels, Ralph William Timmerman, K. F. Wasmuth.

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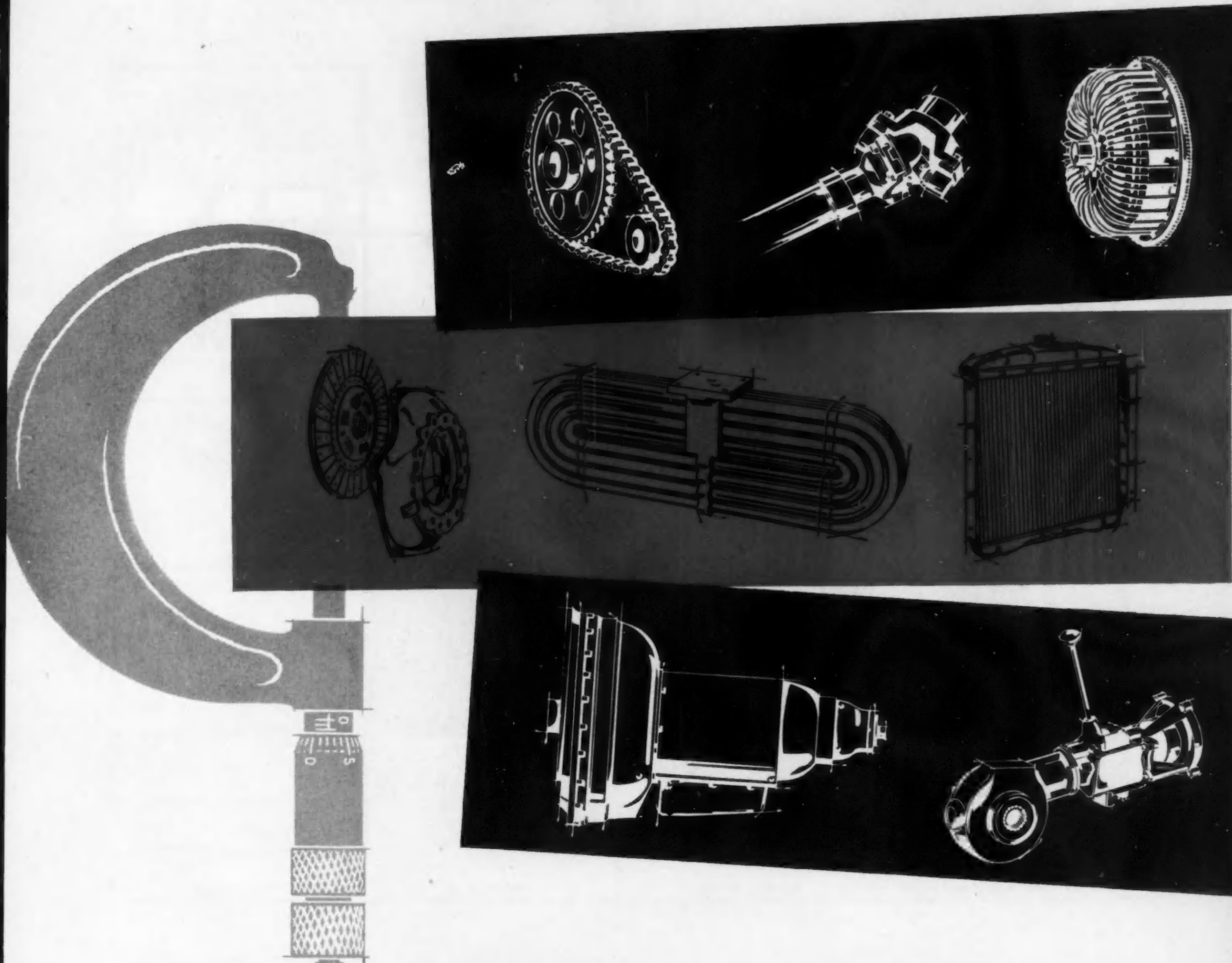


Applications Received

continued

Mid-Continent Section

Gerald Lynn Smith.

Mid-Michigan Section

Lawrence B. Socha.

Milwaukee Section

Charles F. Alexander, Jr., Jerry Fairley, Alfred W. Hubbell, Arthur John Klenner, Clifford Henry Lorenz, Richard Herbert O'Brien, David L. West.

Mohawk-Hudson Section

Elmer J. Phillips, John Edward Zweig.

Montreal Section

George Alexander Adams, Angelo Bozzer, Leo Paul Caron, Barrie R. B. Hall, J. E. Lavigne, John Wylie Noonan, Frank Sicard, Richard Spoonamore, Thomas Anthony Threapleton, Gerard Vaillancourt.

New England Section

Myles Anderberg, Thomas M. Buckeridge, Leon R. Wood.

Northern California Section

Ralph John Barsotti, Walter E. Vance.

Northwest Section

Earl A. Parker, Jr., George H. Weaver.

Philadelphia Section

Manette Brandt, Bruce O. McCracken, Harold Oslick.

Pittsburgh Section

James B. Austin, Allen William Kyllonen, Russell L. Mathias, D. L. Moses, William J. Scovron.

St. Louis Section

T. J. Busch, Wayne P. Killian.

San Diego Section

Robert Raymond Carpignano, Forest Charles Harris, Rodney B. Hutchinson, Jack Allen Perkins, Paul C. Sitton.

Southern California Section

Warren V. Boughton, George C. Chalmers, Theodore F. Fore, Nelson H. Shappell, Glenn E. Struble, George A. Whaley, Jr., Josef E. Wuerer, Tom Yearian.

Southern New England Section

Henry H. Adams, Jr., Carter T. Bragdon, George John Fabian, Howland Seymour Foote, Ronald B. West, Donald L. Witt.

Syracuse Section

Donald L. Miller.

Texas Section

W. M. Bludworth, W. S. Dixon, Carl H. Fox, William Raymond Janowski.

Texas Gulf Coast Section

Irving Pollock.

Twin City Section

Arthur H. Abrahams, Delton G. Crosier, Robert W. Thornburg.

Outside of Section Territory

Albert L. Arbaugh, Richard L. Fisher, Jr., Leonard I. Gatzke, Walter H. Jogwick, Ronald P. Lenert, William E. Partridge, William L. Snider.

Foreign

Roy Lenton Ashley, Australia; Farid Khan, Pakistan; Monty I. Prichard, England; V. Kuppu Rao, So. India; B. L. Maheshwari, India.

Here N-A-X FINEGRAIN *steel proves its versatility, forming readily under the deep-drawing operation that pressure cylinder manufacturing requires. For 20-lb. cylinders, .086" N-A-X FINEGRAIN blanks, 21¼" in diameter, become 12" in diameter and 7½" in depth after the drawing operation. Steel Cooperage Division produces cylinders up to 425-pound capacity.*

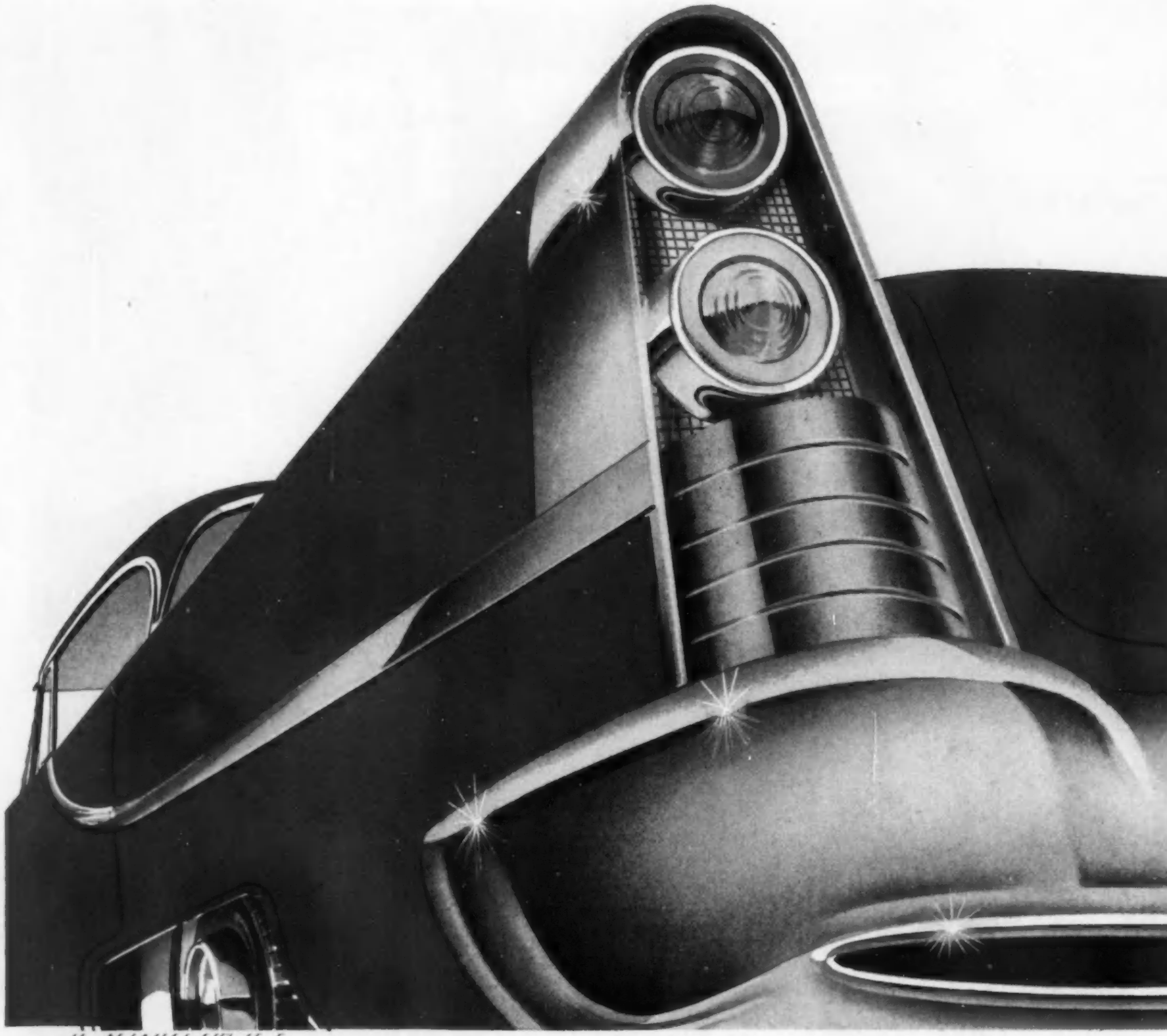
Submerged arc welding operation joins the two cylinder sections together. N-A-X FINEGRAIN *again demonstrates its weldability under any process.*

Here cylinder pressure capacities are tested hydrostatically at 480 lbs. psi, after the fittings have been added. Final burst pressure—1650 lbs. psi.

Finished product on the job. This cylinder, meeting all specifications of I.C.C. code, Section 4BA, contains liquefied petroleum for materials handling truck.

The Convair B·58—"HUSTLER"

DANA We are there



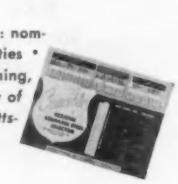
The beauty of Crucible stainless steel is its superior resistance to corrosion

Why do today's cars have as much as 55 lbs. of stainless steel per car? Because this metal is strong but lightweight, beautiful and durable, highly resistant to corrosion. It's the ideal metal for wheel coverings, window frames, top and body trim, grilles, taillight housings, bumper guards and instrument panels.

Tomorrow you'll be using even more pounds per car. For example, you may be able to use it for posts and pillars, chassis frames, floor and roof deck panels. And the beauty of designing with stainless is that your designs can easily be produced because of fabricators' extensive experience with this versatile metal.

Keep abreast of new developments in stainless steel by ordering *Crucible sheet and strip*. Crucible promptly supplies standard grades and finishes in practically any width and thickness. And if design and fabrication problems arise, Crucible engineers and research teams will cooperate with you in every way.

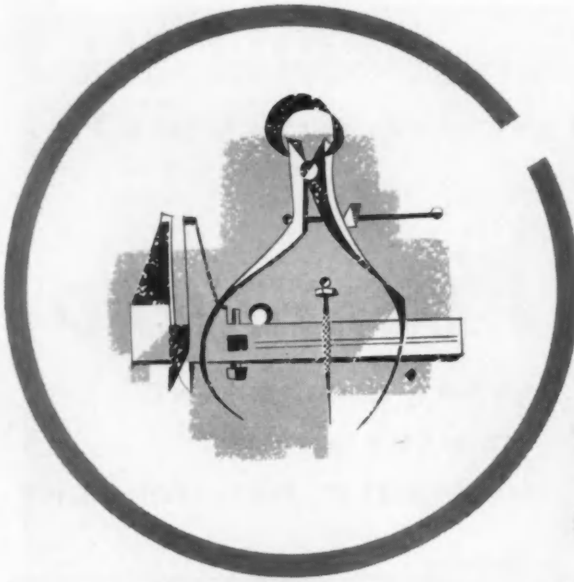
Free *Stainless Steel Selector* contains complete data: nominal composition of all grades • physical properties • resistance to corrosion, scaling • data on machining, welding, hardening. Write: *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

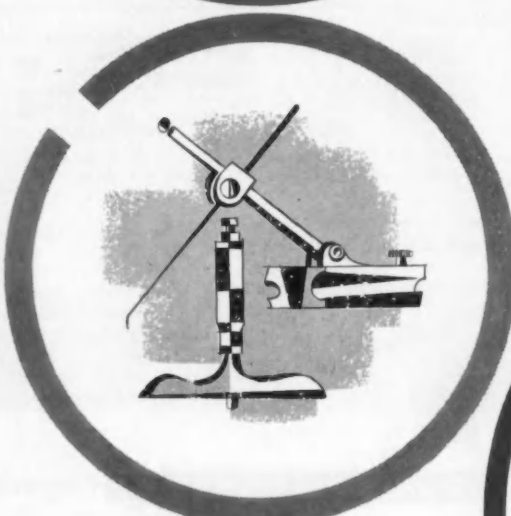


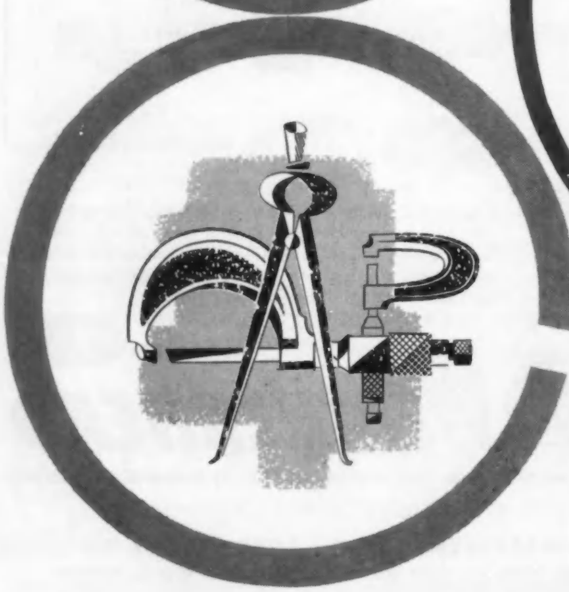
CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.







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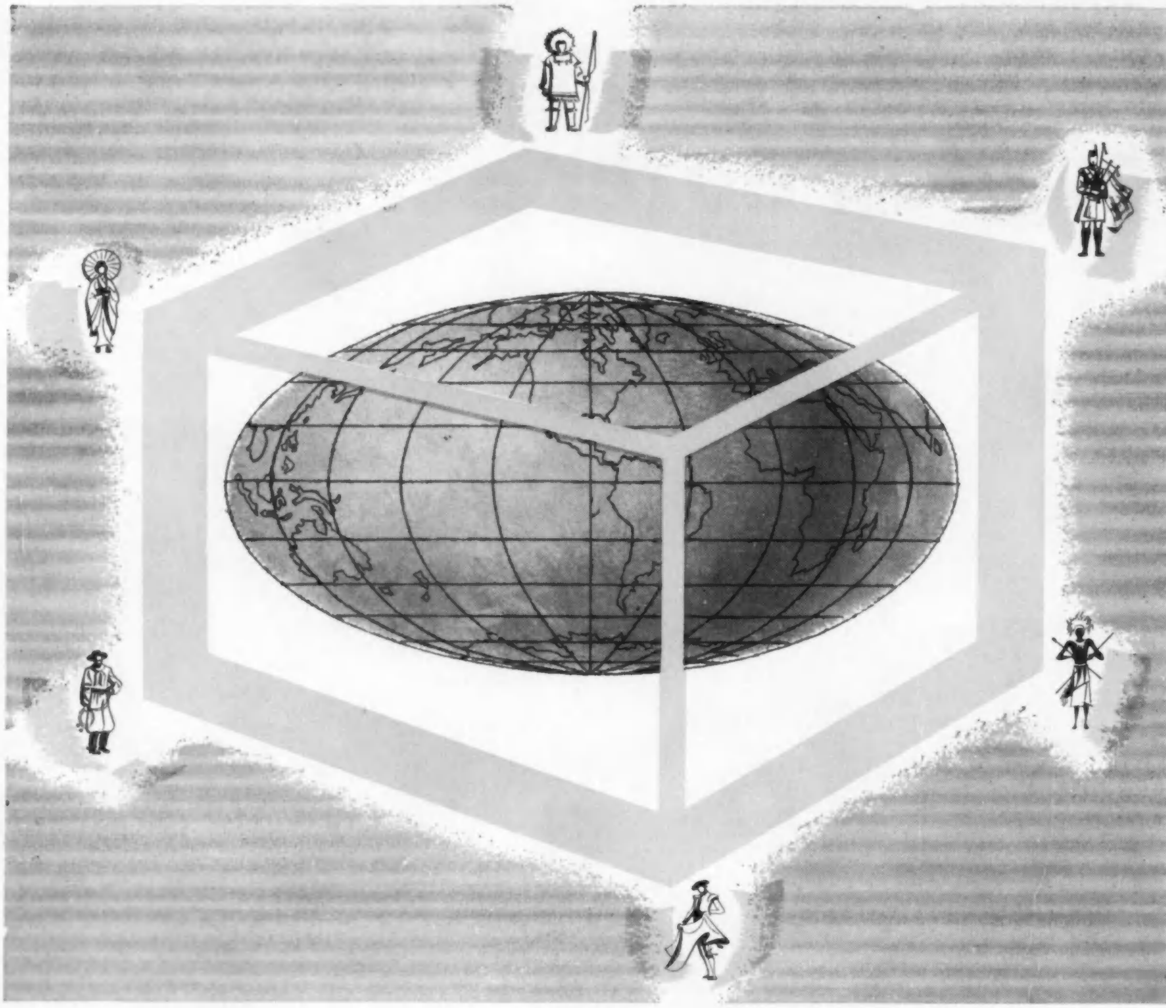


How to detect and measure flange bending in gasketed joints

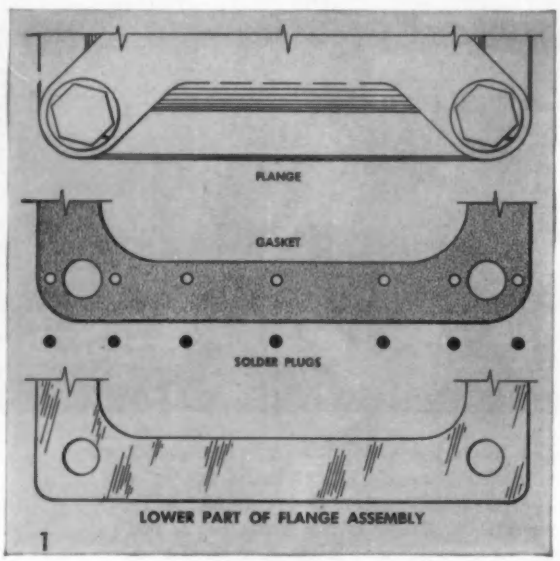
A surprisingly large percentage of gasket leaks is caused by almost undetectable bending or bowing that occurs between flange bolts, according to tests conducted at the Armstrong Research and Development Center.

Obviously, bending is most likely to be found where flanges are light, where bolts are widely spaced, or where bolting pressure is high. But it can also occur in heavy flanges, where bolts are not properly spaced.

Flange bending can cause leaks because it reduces the flange pressure on a gasket in the area midway between bolt holes and thus reduces gasket compression. Also, it may cause extrusion of the gasket near the bolts because of the concentrated pressure in these areas.

There are three qualitative ways and one quantitative way that an engineer can determine if flange bending is taking place.

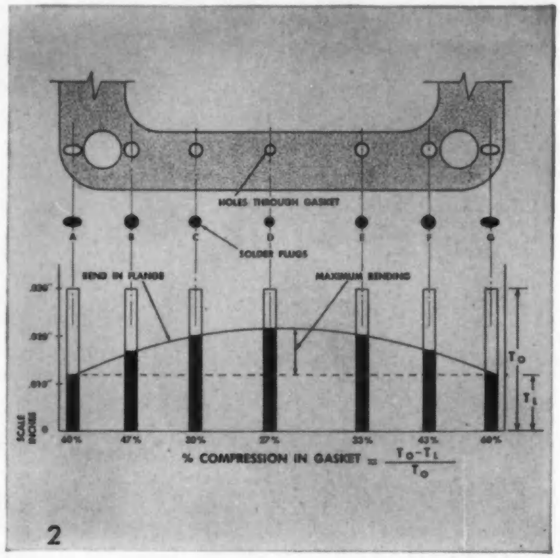
1) *Pinpoint the leakage.* If leaks originate at center points between bolts, there's good reason to believe that flange bending is the source of trouble.
2) *Look for localized extrusion.* Extrusion near bolts—and not at midway points—indicates that flange bending is present.
3) *Check for varying gasket adhesion.* Flange pressure is one of the factors causing gasket adhesion. Consequently, where pressure is greatest, greatest adhesion should occur. If upon opening a leaky joint the gasket is found to be sticking more around bolts than at center, flange bending probably is occurring.



1

TO QUANTITATIVELY MEASURE FLANGE PRESSURE or gasket compression at any particular point, a simple yet accurate "solder plug" test devised by Armstrong research engineers can be used.

Drill several holes about 1/32 inch in diameter through thickness of gasket to be tested. Insert in these holes cylinders or plugs of soft solder. (Fig. 1) The plugs should be thick enough so that when the flanges compress the gasket, the plugs will also be compressed. Put gasket with solder plugs into flange and tighten bolts to desired torque.



2

Open the flange and measure thickness of solder plugs. Each plug obviously will measure exactly the same as the compressed thickness of the gasket at the point where it was located.

The extent of flange bending can be shown graphically by charting the solder plug thicknesses. (Fig. 2) If too much bending occurs, gasket will be overcompressed around bolts and undercompressed between bolts.

The percentage of compression can be easily calculated by using the formula in Figure 2. With this information, it is possible to determine whether the gasket material is within its recommended range at specific locations on the flange. The load-compression curves for the gasket material in question may be used to estimate unit loads. But these are relative unit loads and not absolute values. In addition, picking unit loads from load compression curves is applicable only to the compressible gasket materials such as cork composition.

SEND FOR 1957 EDITION OF "ARMSTRONG GASKET MATERIALS"

This 16-page booklet discusses the choice of proper gasket materials and describes Armstrong cork, cork-and-rubber, synthetic rubber, and fiber sheet materials. Included are government and SAE-ASTM specifications. Look for this booklet in Sweet's product design file. Or for a personal copy, write Armstrong Cork Company, Industrial Division, 7209 Durham St., Lancaster, Pa.

Armstrong

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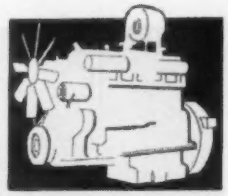
For every engine,



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Veeder-Root Rev-Counters are available with *tachometer take-off* . . . and may be geared to your own engine requirements. Count on Veeder-Root for any assistance you need in designing these Rev-Counters into your product. Write:

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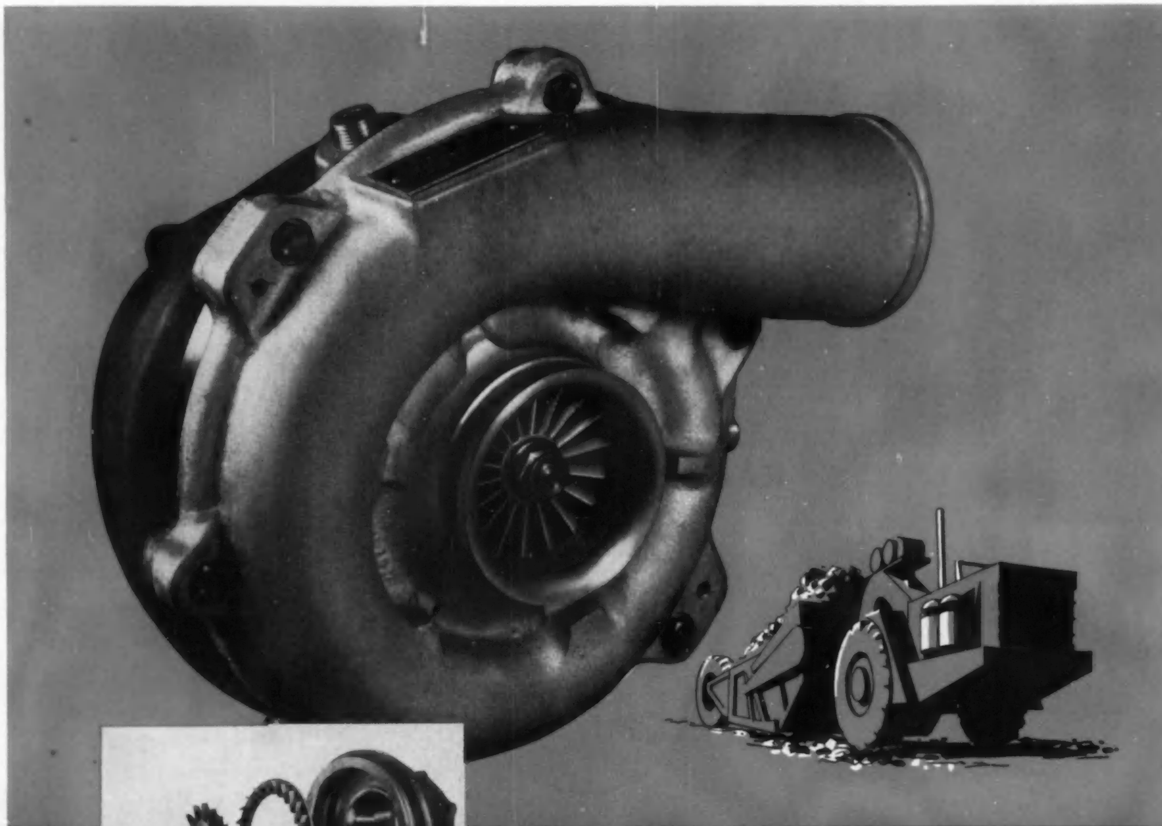
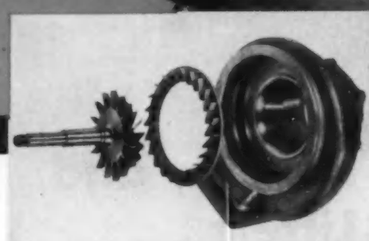


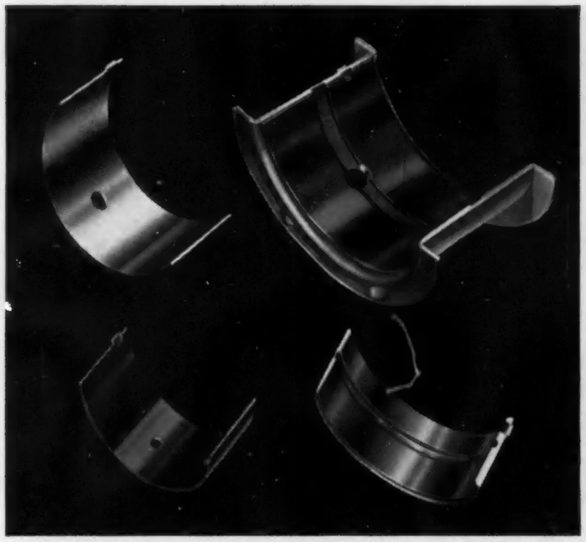


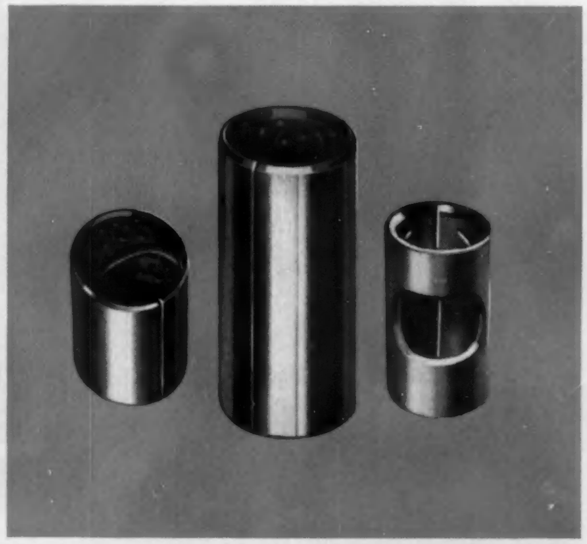
Three alloy linings meet 95% of engine bearing needs

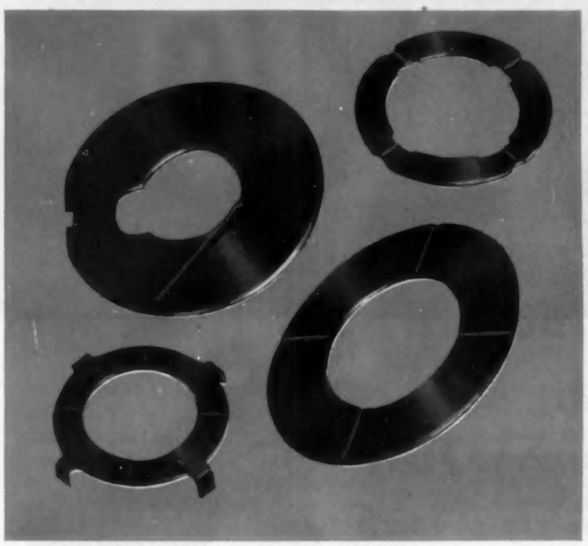
Experience shows a steel back lined with tin- or lead-base babbitt or copper-alloy meets performance requirements.

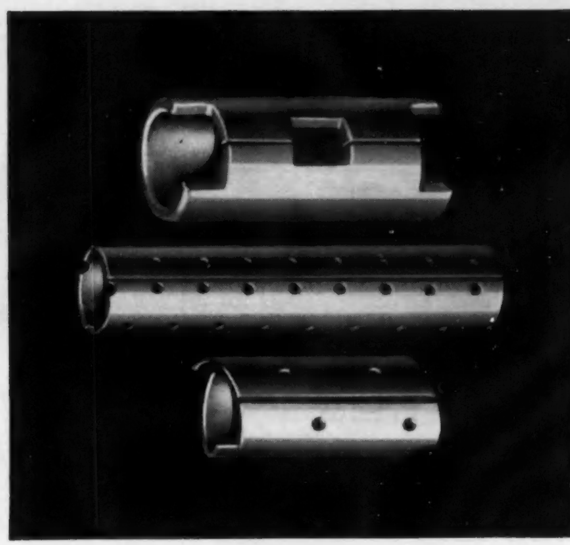
Bimetal and Plain Bushings offer substantial economies

Rolled split plain bronze, steel or aluminum; or steel lined with bronze, babbitt or copper-alloy. Many design variations possible, plus volume production economies.









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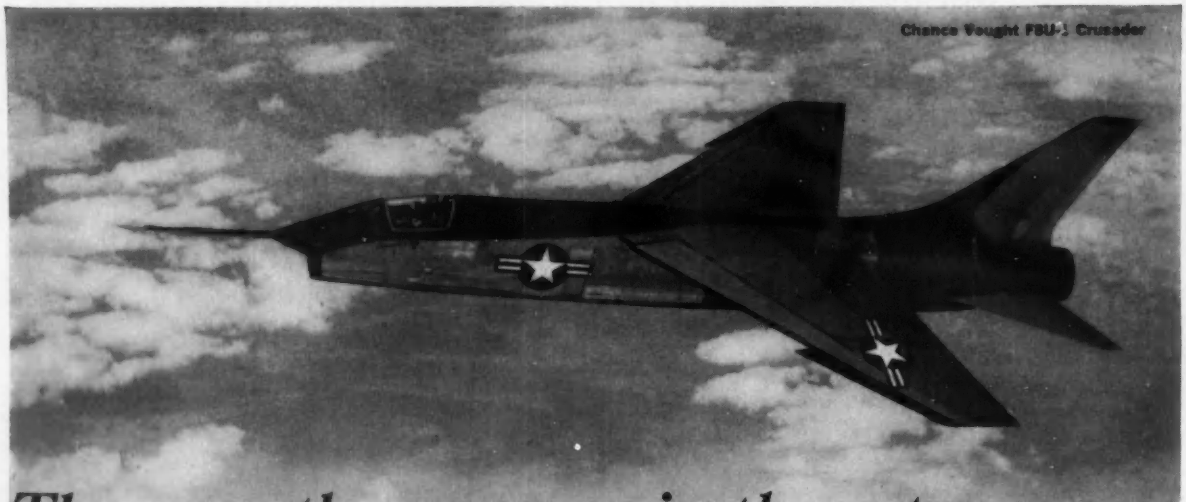
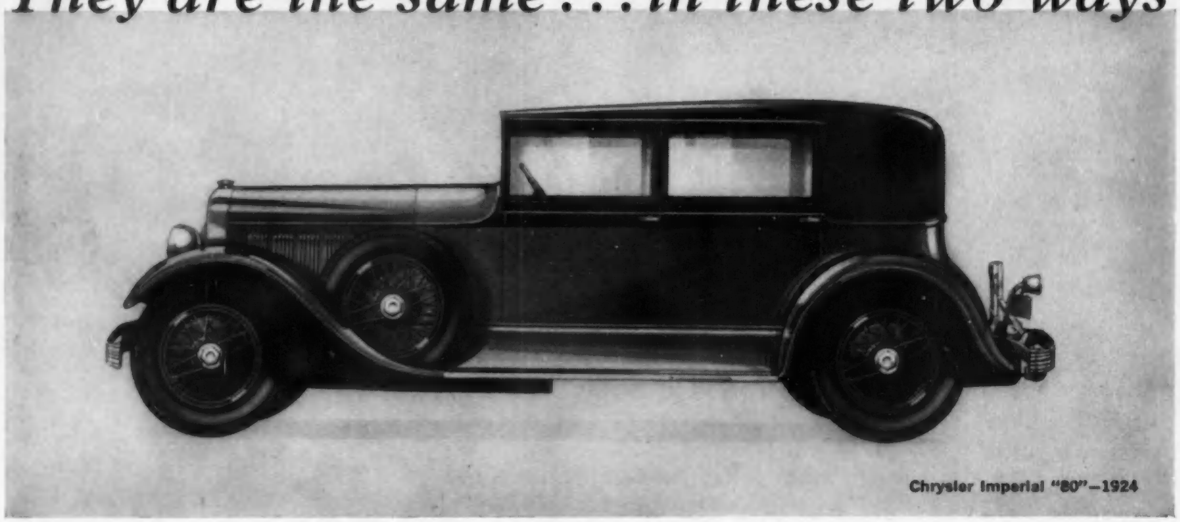


They are the same . . . in these two ways



. . . engineering leadership and filtration by Purolator!

Thirty-four years ago, that Chrysler came off the assembly line equipped with something entirely new: an oil filter. By 1956 when the Chance Vought F8U-1 Crusader shattered the national speed record, filters were accepted as basic components on all automobiles and aircraft. Both events were milestones — both vehicles were protected by Purolator.

The 1924 Chrysler seems a relic of another age, while the Crusader is as new as tomorrow. But the concept that got its start with the Chrysler has become fundamental everywhere . . . any fluid — be it air, fuel, lube oil, hydraulic fluid or anything else—which is vital to the proper operation of any aircraft, automobile or machine, must be filtered to be kept free of contamination.

Purolator makes filters for every fluid known to man—for use in any conceivable application. The unique background of specialized know-how enables them to produce the best possible filters for the specific needs of the automotive industry — no matter what they are or when they arise.

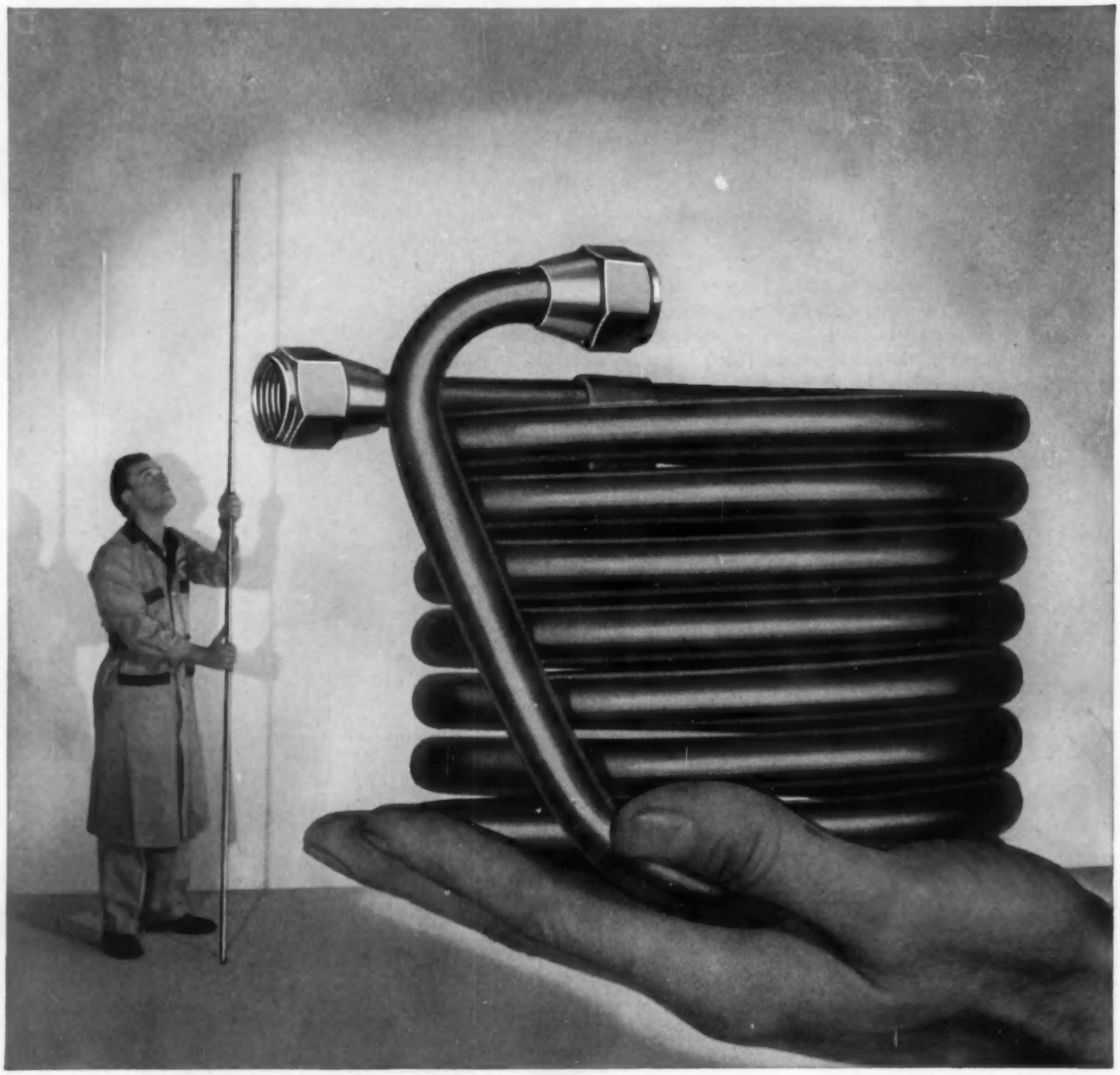
Filtration for Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

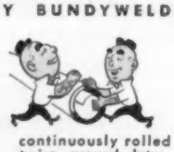
Over 11 feet of ductile Bundyweld



Oil cooler for power-steering unit stands only 4¾" high, yet contains over 11 feet of ½" x .035 Bundyweld Tubing. The inside diameter of the coil measures just 4.88". This I.D. dimension is held to $+\frac{1}{8}$" tolerance. Ends are double-flared with fittings attached.

WHY BUNDYWELD IS BETTER TUBING

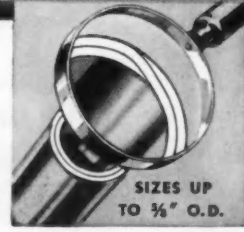
Bundyweld starts as a single strip of copper-coated steel. Then it's . . .



continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.



NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

"30 million Alcoa impacts save

From a *cost* standpoint, aluminum door frames offer the advantages of tooling simplification, flexibility of styling modification, economy of construction, integration of design (rail, inner and outer trim molding, for example, can be combined into a single aluminum extrusion). From a *sales* standpoint, aluminum door frames will not rust, chip, pit, peel or flake. There's added customer appeal in this lasting beauty feature.

Strong, lightweight aluminum door frames are but one of many examples of how the automotive industry is adding beauty, cutting costs and increasing design freedom with both aluminum mill products from Reynolds and with parts fabricated and finished by Reynolds Aluminum Fabricating Service.

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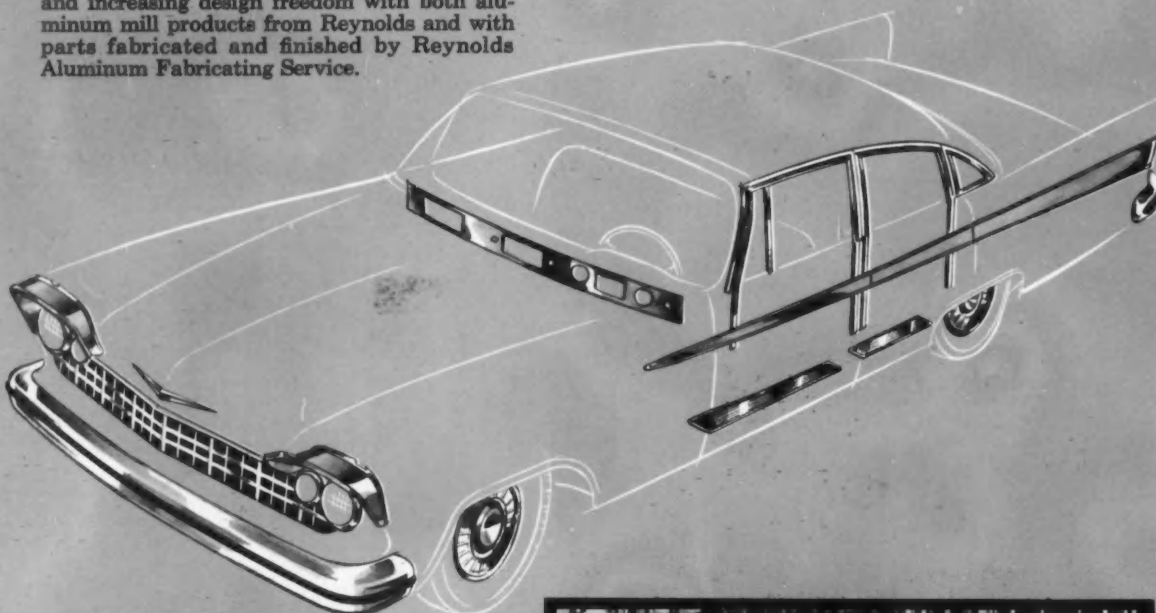

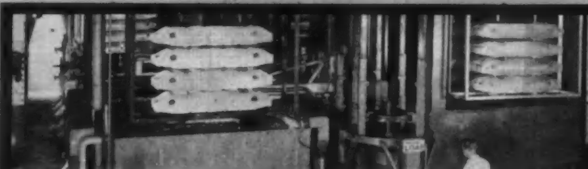

This new Reynolds automatic aluminum finishing system can finish mixed sizes and types of automobile parts and chemically brighten or anodize them in different colors—and can handle several different jobs at the same time. An automatic coding system establishes the individual finishing specifications for each job.

Part of a battery of Reynolds new high speed buffing equipment used here on 1957 hood moldings.

Part of a battery of Reynolds high speed coil fed presses used in the fabrication of automotive parts.

The tanks in this new Reynolds anodizing installation can handle parts 24′ long, 12′ high and 4′ wide, making it possible to handle hundreds of trim parts at one time. This half-block long system is another new addition to Reynolds multimillion dollar finishing facilities investment.

The photos here illustrate examples of the vast fabricating and finishing facilities that Reynolds offers the automotive industry. From these facilities come sales appealing *color anodized* parts with the "gleam of gold" and *clear anodized* parts with the "look of sterling." From these facilities come *quality* parts . . . quality controlled from mine to finished part and backed by Reynolds technological know-how in producing and fabricating aluminum. *Economical* parts, too, because of Reynolds tremendous variety of the most modern fabricating and finishing equipment.

For details on these facilities and for the assistance of Reynolds Aluminum Specialists on mill product applications or on fabricated parts, contact your nearest Reynolds Office. Or write *Reynolds Metals Company, Fisher Building, Detroit 2, Michigan* or *Reynolds Aluminum Fabricating Service, 2009 South Ninth Street, Louisville 1, Kentucky.*

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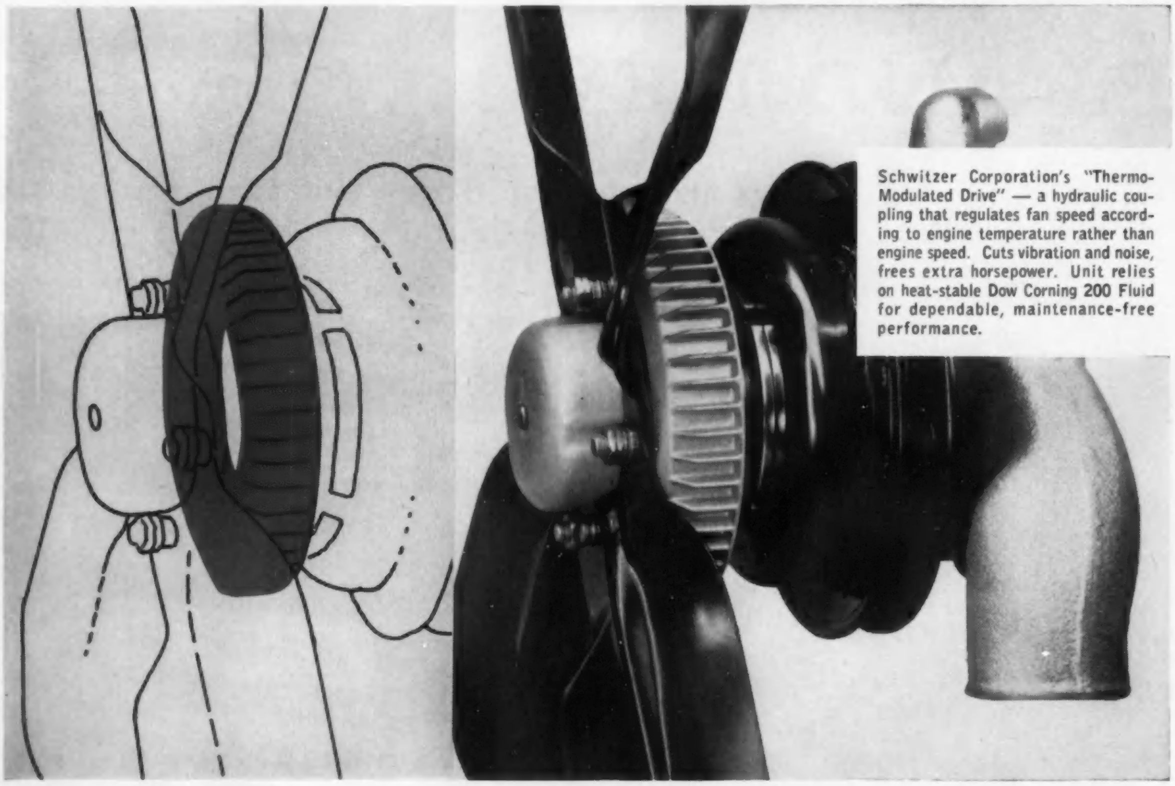

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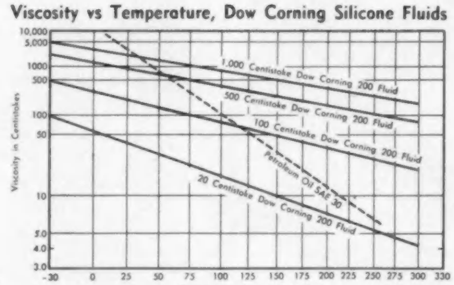

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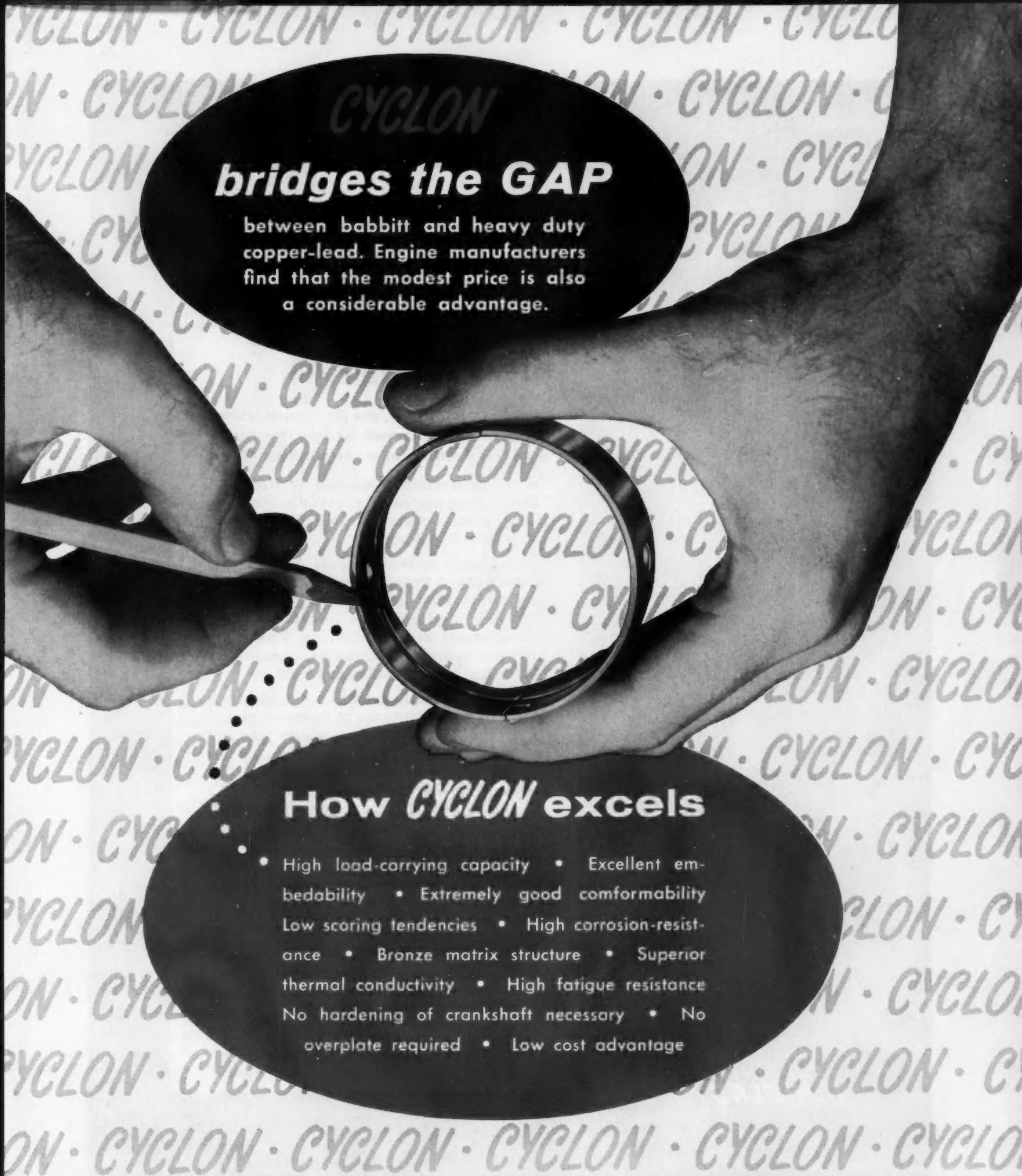
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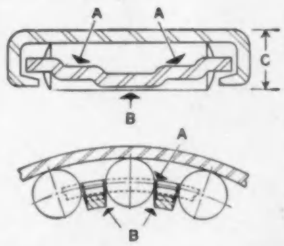

- rollers end-guided at pitch line (A)
- shaft-riding retainer (B) designed to permit lubricant circulation
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- simple housing design
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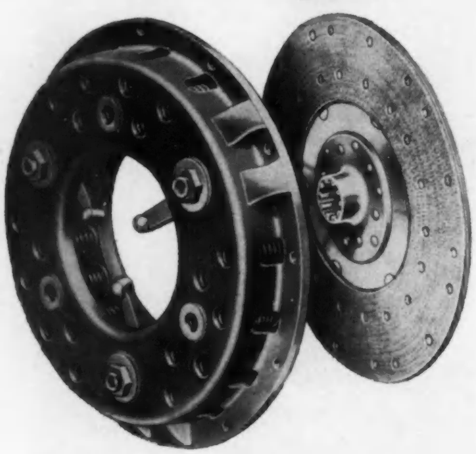

"Since July, 1955," says Mr. Stoddard, "we have some 100 more heavy units equipped with the Lipe Direct Pressure Clutches. Some sixty units were so equipped as original specifications, with the remainder being change-overs from other makes and types of clutches.

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AMS 4384, MAGNESIUM ALLOY SHEET, HK31A-O

AMS 4385, MAGNESIUM ALLOY SHEET, HK31A-H24

Copies will be available on request at this time. However, these specifications will be included in the set of New and Revised AMS specifications that will be released shortly after September 15.

You may purchase these specifications from the

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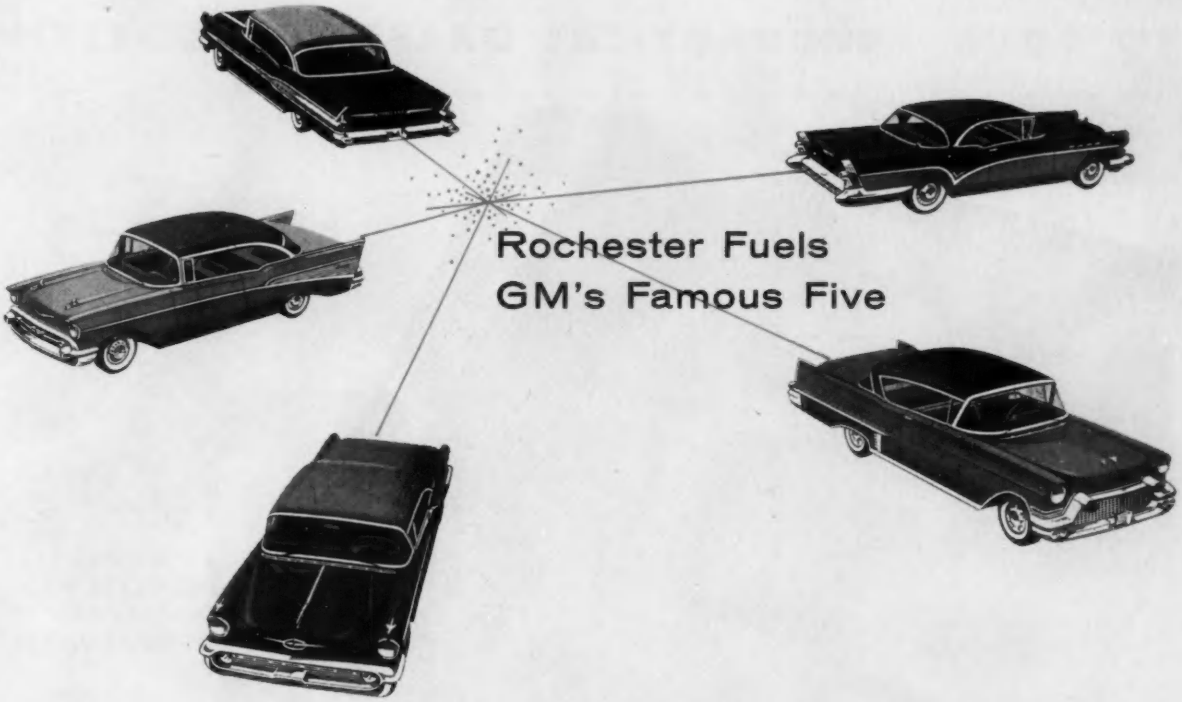

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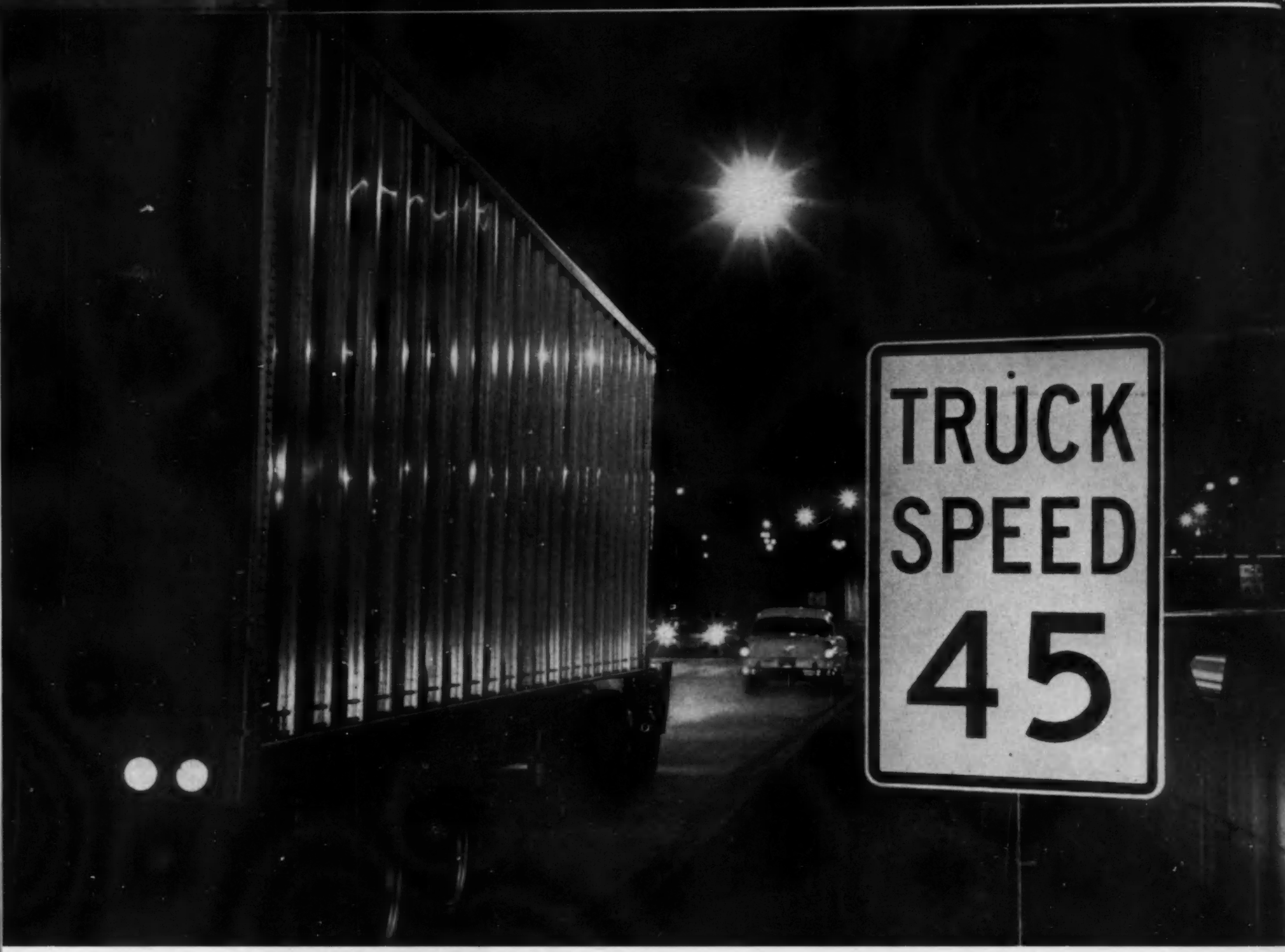

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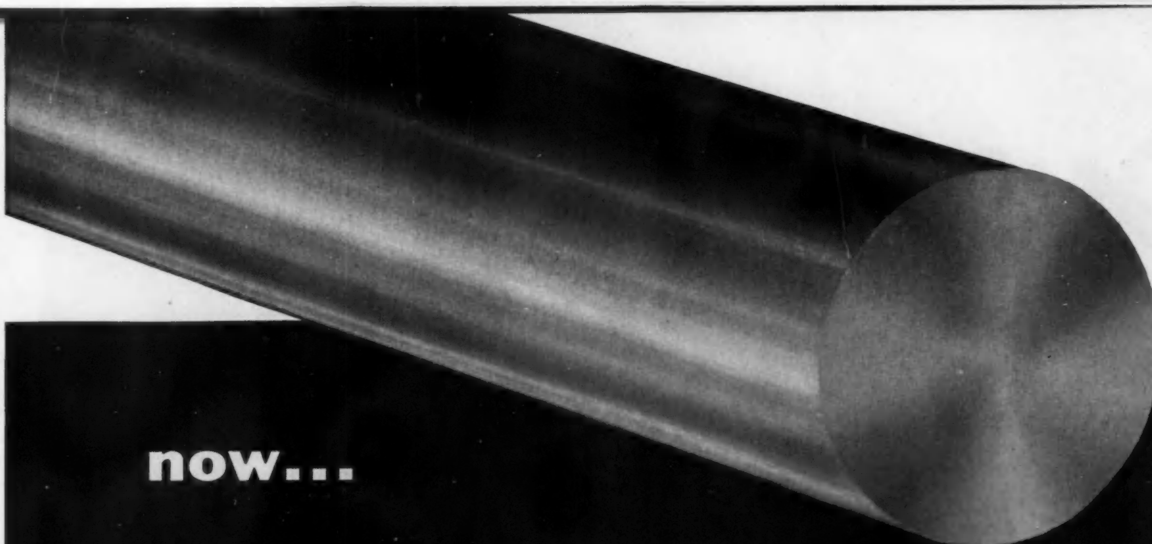

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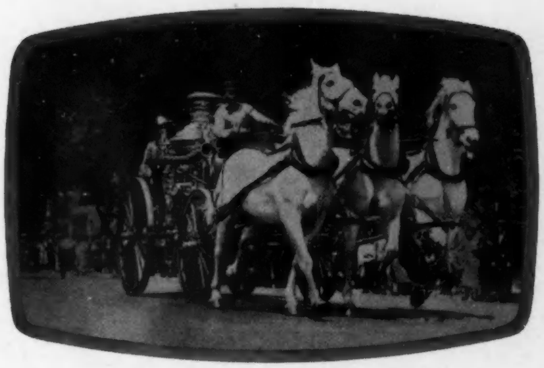

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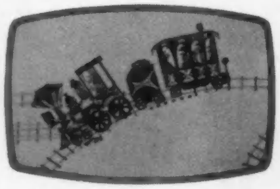
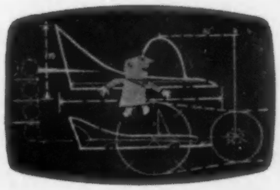
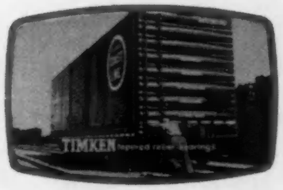


See Why America's railroads have always led the world.



See Why Americans jump for the latest thing in cars.



See One man push a freight car all by himself.

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